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FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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The common experiences of normal people are the matter of science—H. Dingle

CONTENTS *for* JUNE, 1935

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School Science and Mathematics

Vol. XXXV — June, 1935 — Whole No. 305

THE CHICAGO CONVENTION

The thirty-fifth convention of Central Association of Science and Mathematics Teachers, Inc. will be held in Chicago, November 29th and 30th, 1935. The Palmer House has been selected as headquarters hotel and all the meetings of the convention will be held there. The Palmer House is one of Chicago's most attractive and popular hotels. It is located in the heart of the loop district, is within two blocks of the theatre and the shopping districts, is on the elevated lines, and within five minutes of the depots. We believe that in making this selection we have provided not only for the physical needs of the convention but that we have made it possible for our members and their guests to enjoy some of the advantages the city has to offer.

Mr. John Skinner, Senn High School, Chicago, is chairman of local arrangements. The Grand Ball Room of the Palmer House has been reserved for all the general sessions of the convention and for the annual dinner. Large rooms have been set aside for the Friday afternoon section meetings. Exhibitors and members will be pleased with ideally located exhibition space in the large foyer at the entrance to the Grand Ball Room.

The general and the section officers are busy planning the program. Although it is too early to announce speakers, things are shaping up in such a way that this promises to be one of the most profitable and enjoyable of conventions. Details concerning the program will appear in the October issue of this Journal.

The membership committee, headed by Mrs. Marie Wilcox, George Washington High School, Indianapolis, is swinging into action again. In addition to the "spring drive" there will be a

very general and intensive campaign next September and October. Last year several states—notably Wisconsin and Indiana—doubled their membership. Teaching conditions are improving in all sections of the country and this is resulting in renewed interest in professional organizations of all types.

During the past thirty-five years Central Association has developed from a small local group of enthusiastic teachers into a large association of influential teachers representing all the Central States. We now (since 1929) own, edit, and manage our own magazine—SCHOOL SCIENCE AND MATHEMATICS. To the editor and his departmental staff, to the business manager, and to the journal committee, is due the greater share in the success of the journal. In large measure, however, the successful development of the Association as a whole has been due to the continued efforts of our members who realize that only through intelligent cooperation can an enduring and progressive organization continue to be an influence in the educational progress of the Central States.

We invite all progressive teachers of science and mathematics to join us and become active in our organization. Send in the membership blank (page 670) and become a member *now*. Plan *now* to meet with us at the Palmer House next November.

Sincerely yours,

KATHARINE ULRICH, *President.*

THE HUDSON RALLY

March 16 the science and mathematics teachers of the Cleveland district led by Cap'n Bill Vinal of Nature Guide fame, R. B. Simon, Hudson Academy, Professor Harry Cunningham, Kent Normal, F. R. Bemisderfer, East Tech, Dr. Ellis Persing, Western Reserve School of Education, Science Questions Editor Jones and other stalwarts of the Central Association met at Western Reserve Academy Chapel, Hudson for the annual spring meeting, nature hike, and sugar-off dinner. E. O. Bauer was in charge of reservations.

The principal discussion of the day centered around the topic, "Relative Importance and Contribution of Mathematics, Science, and Social Science in a Progressive Curriculum." Supt. Fred Bair, Shaker Heights, Supt. Geo. Bowman, Lakewood, Dr. Henry Harrap, W.R.U., Dr. Harry Cunningham, Kent, R. A. Mickel, W. R. A., W. O. Smith, South High, F. R. Bemisderfer, East Tech, and Irl Fast, Heights High took part in the discussion. The Mathematics Club of Greater Cleveland combined its March meeting with the Hudson program. Over 200 teachers and friends of education attended. G. G. Rush, West High was selected as leader for next year. It was an enthusiastic, profitable meeting carried out in the energetic style characteristic of the Queen City of the Lakes.

A DEMONSTRATION MODEL FOR GENETICS

By Thomas F. Morrison
Milton Academy, Milton, Massachusetts

In view of the highly technical nature of the subject-matter of Genetics, this has been considered a rather difficult branch of Biology to teach to Secondary School students. This difficulty is increased, furthermore, by the fact that relatively little inexpensive material for demonstration is available for schools and this, when available, is apt to be of a nature which does not lend itself easily to illustrating cases other than the one for which it has been developed. In other words, when cheap material is available, it is frequently of such a nature that it does not show more than one pair of factors at a time and, hence, cannot be used in illustrating conditions other than those for which it has been specifically designed. Experience has shown, however, that if some schematic device which employs *objects* to represent factors instead of the actual material is used, the students have little difficulty in imagining the factor which the object is supposed to represent.

Based on the assumption that the student finds it easy to visualize the inheritance of some factor by the use of a representative object, the writer has developed the Genetograph which is described in this note. This piece of demonstration apparatus can be used to show any monohybrid cross or the inheritance of any sex-linked characteristic. Its ease of construction, as well as its inexpensiveness recommends it to the school with limited finances. From the teaching standpoint, it has proven valuable because it enables students to visualize what occurs during the various processes which are of importance in genetics.

As constructed by the writer, the back of the Genetograph consists of a piece of wall-board 36 inches square, and into this were screwed curtain-rod hooks at the points indicated in Figure 1. On these hooks were hung poker chips which had been bored with holes large enough to fit easily over the hooks. In demonstrating a simple monohybrid cross only red, and white chips were used, but when discussing sex-linked inheritance, red, white, and blue chips were used for a reason which will appear later.

When explaining the inheritance of a single pair of contrasting

characteristics, each chip represents a *gene*. Thus, in the Parental Generation (P) two red chips are used to designate the homozygous condition found in one parent while two white chips show that the other parent is homozygous for the contrasting characteristic. Knowing the difference between the haploid and diploid numbers of chromosomes, the reason for duplicating the chips in each of the parents is clearly obvious. Let us consider that the red chips represent the dominant pair of chromosomes.

Below the hooks which represent the Parental Generation are placed four hooks, one pair above the other. On the upper pair are hung two red chips with two white ones immediately

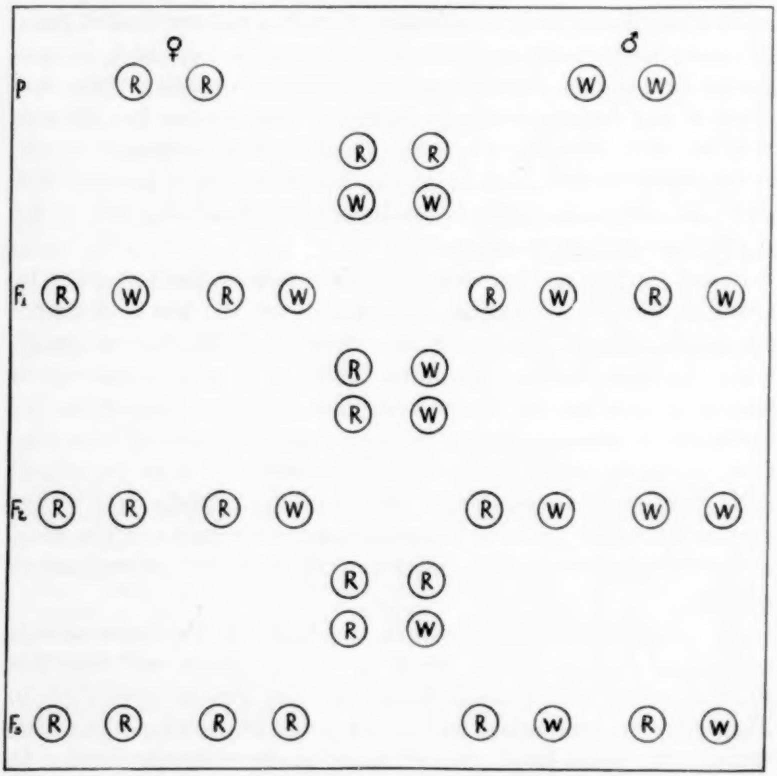

FIG. 1. Genetograph arranged to show a simple monohybrid cross. R = red chips which represent the *dominant* factor; W = white chips designating the *recessive* factor; P, F_1, F_2, F_3 = Parental, First Filial, Second Filial, and Third Filial Generations. As arranged now, the chips in the F_3 group show the results of a cross between a homozygous dominant and a hybrid.

below them. Now, if the red chips represent the dominant factor found, in this case, in the female, after reduction division each mature ovum would contain one determiner for that particular characteristic. Therefore, each red chip now represents the condition found in the individual ovum. The same applies to the sperm cells. After maturation each sperm cell receives one gene for the recessive characteristic, hence, each white chip represents an individual sperm.

Fertilization can be shown by a combination of the red and white chips. Four such combinations are possible, each resulting in a pair of chips composed of one red and one white. The influence of the dominant characteristic can now be illustrated by hanging the red chip over the white chip on the line of hooks marked F_1 thereby hiding the white chip and showing that while the dominant factor is the one which appears in the phenotype, the recessive is still borne by the genotype. All of the members of this First Filial Generations can therefore be shown to be hybrids.

To show the condition found in the Second Filial Generation (F_2), the process used to demonstrate the F_1 generation is repeated with this exception: instead of using a pair of red and a pair of white chips, each pair is composed of one red and one white chip (hybrid condition). The results obtained by combining these two pairs is shown in the line marked F_2 in Figure 1. We find here that segregation is illustrated in the following fashion. On the first pair of hooks to the left is hung a pair of red chips (homozygous dominant), on each of the next two pairs of hooks there is a pair of red and white chips (heterozygous), while on the pair of hooks to the extreme right is a pair of white chips (homozygous recessive). Since three of the four pairs of hooks contain red chips it is evident that there are three dominants to one recessive; also, since there is one homozygous dominant, to two forms which are heterozygous, to one homozygous recessive, we have illustrated the second Mendelian ratio of 1:2:1. Further rows of hooks may be added, if so desired, to show other combinations such as the results of crossing hybrids with either homozygous dominants or homozygous recessives.

This same chart may be used to show the mechanism of inheritance of a sex-linked factor such as Daltonism. In these cases, however, a somewhat different procedure is followed. When we considered the inheritance of characteristics which adhered strictly to the Mendelian Laws, each chip represented a

gene, but when we take up the subject of sex-linked factors, each chip must represent a *chromosome*.

In sex-linkage there are really three kinds of chromosomes concerned: the normal X-chromosome, the normal Y-chromosome, and the X-chromosome which acts as a determiner for the characteristic. The method of representing these three different types is to call the red chips the normal X-chromosomes, the white chips the normal Y-chromosomes, and the blue chips the X-chromosomes which act as determiners. Using this color scheme, the normal female would be represented by two red chips, the normal male by a red chip and a white chip, the male showing the characteristic by a blue chip and a white chip, and the female "carrier" would be shown by a red chip and a blue chip. Figure 2 gives a diagram of the Genetograph as it

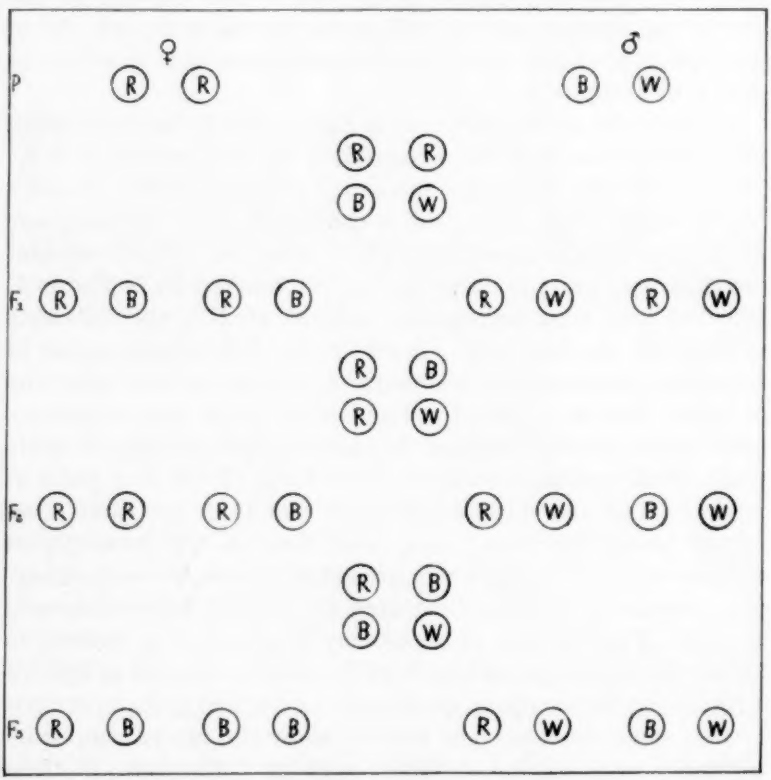

FIG. 2. Genetograph arranged to show sex-linkage as found in Daltonism. RR = normal female; RB = female "carrier"; BB = color-blind female; RW = normal male; BW = color-blind male. (R and B represent two different X-chromosomes while W designates the Y-chromosome.)

would appear in the case of Daltonism (red-green color blindness). It will be noted that the lower rows of hooks can be used to demonstrate combinations which are possible, but which do not commonly occur.

The total cost of the Genetograph as first made by the writer was about two dollars. This included the cost of poker chips made from a composition material, a more expensive article than need be used unless the board is to see hard service. The pasteboard chips which can be purchased at chain stores are sufficiently good for average use.

CONSERVATION POLICIES OF THE NATIONAL PARK SERVICE*

By H. C. Bryant
Assistant Director, National Park Service
Department of Interior, Washington, D.C.

A prime duty of the National Park Service prescribed by law is "to conserve the scenery and the natural and historic objects and the wild life" of the areas under its jurisdiction. Consequently all plant and animal life is given protection. Predatory animals which elsewhere are eliminated are protected within park areas in order that the fauna may be presented unmodified.

Typical wild life problems pertain to the herds of wapiti, commonly called elk, which migrate to concentrated winter feeding grounds often outside the parks, and to black bears in Yellowstone which become pests to the camper when artificially tamed and fed. These problems are receiving continuous attention and improvement is apparent.

Sometimes opportunity is afforded to aid a disappearing species to recover by giving it complete sanctuary. The trumpeter swan was nearing extinction throughout the United States when about six years ago a pair was found nesting on a Yellowstone lake. The birds were unsuccessful, but the following year a ranger patrolled the area and the young were reared successfully. More and more trumpeter swans have nested in the Yellowstone region indicating that the special attention given this bird has resulted in reestablishing it.

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* Summary of an address before the Central Association of Science and Mathematics Teachers, Indianapolis, Nov. 30, 1934.

Wherever people concentrate the fauna and flora are injured. Consequently the attempt is made to center the developments in a national park rather than scatter them. Roads and developed areas furnish the accommodations necessary and the rest of the park is considered a primeval area into which no extensive roads or man-made structures are to go.

Most conservation organizations direct their energy to conserving but one type of plant or animal—birds, fish, trees, wild flowers. The National Park Service attempts to conserve the complete biota so that there may be some places where unspoiled and unmodified nature may be enjoyed and studied. Only primeval conditions present suitable opportunity for studying and appreciating the numerous interrelations existing between plant and animal life and its environment.

ECONOMY IN THE PHYSICS LABORATORY

By Clyde E. Riley
Westborough, Mass.

In attempting to keep the amount of maintenance in physics down to a minimum, I have used a procedure which has been decidedly successful. I wish to present it to teachers who have difficulty in obtaining sufficient equipment in the physics laboratory.

The following conditions exist:

(a) The laboratory is equipped with six tables so that twelve groups can work at the same time.
(b) The class is divided into twelve groups and are numbered or lettered.
(c) A series of experiments 'are chosen for a month's work using about 5 to 7 experiments.

Instead of all students doing the same experiment, different groups work at somewhat separate experiments at the same time.

A list of experiments such as the following may be chosen:

(a) The Straight Lever—3 sets of apparatus.
(b) Weight of a Lever and Center of Gravity—3 sets.
(c) Parallel Forces—2 sets.
(d) Inclined Plane—1 set.
(e) Sliding Friction—1 set.
(f) Efficiency of Common Block and Tackle—1 set.
(g) Jack Screw—1 set.

Each side of each bench has a set of apparatus. The poorer students start to work on the required experiments; which are greater in number of sets; the better students start to work at the experiments with only one set. At each period the different groups are assigned to different experiments as their work has been completed. The minimum requirement is four experiments; the maximum seven.

In this way fewer sets of apparatus are necessary for a series of experiments. Still fewer could be utilized if the time or ranking periods were increased to six or eight weeks.

NEW TOTAL INTERNAL REFLECTION DEMONSTRATION

By J. J. Mahoney
Loyola University, Chicago, Illinois

There are several methods of showing total internal reflection of light. Nearly all are complex and expensive. The method to be described is one in which the apparatus is simple, transparent and easily set up, with practically no expense.

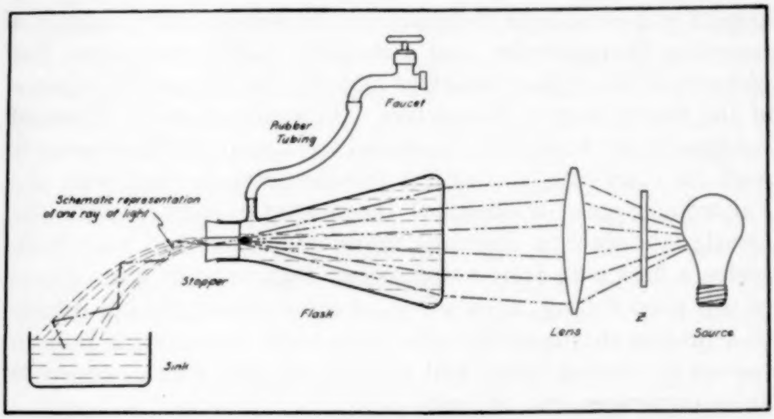

Diagram of Apparatus

The apparatus consists of an ordinary glass filter flask with the side tube of the flask connected by rubber tubing to a faucet. The following simple instructions may be useful. Stand the flask on its base and put a one-holed rubber stopper in the mouth of the flask and turn on the faucet. This removes all air bubbles. Let the water keep on running and turn the flask to a horizontal position and clamp it by the neck. There should be nothing at all in the stopper hole except water.

Most any source of light and lens may be used to focus some light through the flat end of the flask toward the hole in the rubber stopper. The light inside the water stream is incident at an angle greater than the critical angle for water to air. Thus total internal reflection causes the light to follow the stream of water on down to the bottom of the sink. This is the principle of the well known "light fountain."

By using different colored glasses at position "Z" in the diagram, beautiful color effects may be produced.

SUGGESTIONS FOR A UNIT ON THERMOMETERS

By Bertha M. Parker
University Elementary School, Chicago, Illinois

A unit on thermometers can easily be made worth while for children of the intermediate grades. It requires little equipment. Of course, there is a decided advantage in having enough chemical thermometers so that experiments may be carried on by all members of the group at the same time, but the unit can be handled successfully with only a few thermometers. It is helpful to have a fever thermometer, an alcohol thermometer, a recording thermometer, and a metallic dial thermometer, but pictures of these thermometers may be made to serve in place of the thermometers themselves. The really essential items of equipment are an outside thermometer, a mercury thermometer with no markings, a chemical thermometer marked with the Fahrenheit scale, a chemical thermometer marked with the Centigrade scale, a chemical thermometer marked with both scales, a flask with a one-holed rubber stopper to fit, a few pieces of soft glass tubing, a few pieces of thermometer tubing (pieces of a broken thermometer serve very well), mercury, a Bunsen burner or alcohol lamp, and a brass ball and ring designed to show expansion due to heat.

The suggestions which follow are based on the author's experience in handling a unit on thermometers with fourth grade children. No attempt is made, as you will see, to outline in detail every step in the unit. The author hopes merely to suggest ways of making a unit on thermometers, which is sometimes handled in such a way that it is surprisingly dull and uninteresting, into a unit which will really be challenging and which will make a strong appeal to children.

Before the class is told the name of the new unit, try the following exercise. Place three beakers on the demonstration desk. Have Beaker A filled with water which has been standing in the room long enough to have the same temperature as the air in the room. Have Beaker B filled with water which has a temperature of about 130°F. Have Beaker C filled with water which has a temperature of about 40°F. Ask some member of the group to put the fingers of one hand first into Beaker B, then into Beaker A, and to write one word on a slip of paper on the desk to describe the temperature of the water in Beaker A. Do not allow the other members of the group to see the

word. The words "cold," "hot," "cool," and "warm" may be written on the board in advance so that there will be no questions about spelling. Ask several other children in turn to feel the water in Beaker B, then that in Beaker A, and to write a word describing the temperature of the water in Beaker A. Each child should be given a separate slip of paper on which to write. Then ask several children to feel first the water in Beaker C, then that in Beaker A, and to write a word describing the temperature of the water in Beaker A. Show the class the slips of paper. On some will be written "cool" or "cold"; on others, "warm." The children will, of course, be puzzled by the differences of opinion. Suggest that, since the children did not agree about the temperature of the water in Beaker A, others be given a chance to tell its temperature. Ask several children in turn to hold one hand in the water of Beaker A, the other in the air beside it, and to write a word telling whether the water in the beaker is warmer or cooler than the air. As a rule, each child will write "cooler." Then raise the question of how the temperature of the water in Beaker A can be measured. The class will doubtless suggest using a thermometer. The temperatures of the water and the air should then be taken with a thermometer (one marked with the Fahrenheit scale). The children will see that we cannot depend on feeling to tell temperatures accurately. Let all the children feel the water in all three beakers and suggest reasons for the fact that the water in Beaker A felt cool to some and warm to others. Tell the reason for the fact that the water in Beaker A felt cooler than the air. The author has found that the exercises described serve very well to arouse initial interest in the unit.

Ask the class to examine the thermometer used to take the temperatures of the air and the water. Call attention to the mercury. Pour some mercury in a small bowl and allow the class to experiment with it. Let the children find that it can be poured, that it is heavy, that such articles as pennies and pebbles will float on it, and that it will not wet a piece of paper put into it. Pass around pieces of thermometer tubing so that the children may see how small the bore is. Let them try sticking a pin in the bore. Discuss the reason for the fact that the column of mercury in a thermometer looks larger than it is.

As a help in working out with the class an explanation of how a thermometer can tell temperature, ask some member of the group to heat the brass ball and try to push it through the

ring. After the ball has expanded so that it will not go through the ring, ask for suggestions as to how it can be made to go through the ring. The class should suggest not only cooling the ball but also heating the ring. Test the suggestions.

Give some member of the group, John, let us say, the thermometer with no markings, and ask him to find the temperature of his hand with it. Ask how, with this thermometer, John can find out whether his hand is hotter or colder than Robert's. The class will doubtless suggest marking the top of the mercury column with wire, string, or a tiny strip of gummed paper. The class will see that thermometers can be used to some extent even if they have no scales marked on them but that their usefulness is definitely limited unless they are marked.

Before the class is told about the different ways of marking a thermometer, give one member of the group a thermometer marked with the Fahrenheit scale, another a thermometer marked with the Centigrade scale. Ask both children to tell the temperature of the room. There will, of course, be a difference of many degrees. If enough thermometers are available, give each child in the group a thermometer. Write each child's reading on the board. The author has found that a lively discussion is practically sure to follow the listing of the readings. Hold the thermometer which is marked with both scales in such a way that a child who is asked to read it sees only the Fahrenheit scale. Ask him to tell the class his reading. Then ask another child to read the temperature from the same thermometer and hold it so that only the Centigrade scale may be seen. Two different readings from one thermometer will be very bewildering. Then give the thermometer marked with both scales to some member of the group. If he discovers nothing to help solve the problem, ask one child after another to examine the thermometer until someone discovers the letters "C" and "F" at the tops of the two scales. Explain the two scales. Use a ruler marked in inches on one side and in centimeters on the other to help in the explanation. Ask each child to discover whether the thermometer he is using is marked with the Fahrenheit or the Centigrade scale. Let each child mark either "F" or "C" after the figure on the board which represents the reading of his thermometer. The class will see that the different Centigrade readings vary little and that the different Fahrenheit readings vary little. Tell stories of some of the early attempts to mark thermometers—of how Celsius, for example, first

marked freezing temperature 100° and boiling temperature 0°.

Practice reading temperatures. If enough thermometers are available, let each child take the temperature of the air, of the water from the hot water faucet, and of the water from the cold water faucet. Ask the children to write their readings on slips of paper. Compare readings.

The following sentences were taken from a newspaper clipping of some years ago: "The king of Greece is very ill; he has a very high fever. His temperature yesterday was 40°." Ask the members of the group what temperatures they have had when they have had fever. Ask them to explain why the king of Greece had a temperature of only 40° when he had a fever. The discussion will help bring out the fact that the Centigrade scale is commonly used in some countries.

Keep a daily record of the outdoor temperature. Before sending a child to read the temperature each day, allow each member of the group to guess the temperature. Point out that, if there are no evidences of freezing, a guess of below 32°F is a foolish guess.

Make an air thermometer somewhat like Galileo's first thermometer. Insert a straight glass tube in a one-holed rubber stopper in the neck of a flask. Invert the flask so that the end of the tube is in a beaker full of water colored with red ink, and support the flask in position. Let one member of the group drive a little air from the flask by heating it with his hands. Mark the height to which the water rises in the tube by twisting a fine wire around the tube. Place a cloth dampened in cold water on the bulb. Ask the class to explain why the water rises. Place a cloth dampened in hot water on the bulb. Ask the class to explain why the water goes down in the tube. Ask the class to tell why the mercury or alcohol thermometers we commonly use today are more satisfactory than Galileo's air thermometer.

Raise the question of whether water can be used in a thermometer. Let the class devise a way of showing that water expands when heated and contracts when cooled. Discuss the fact that water freezes at a comparatively high temperature.

Look at metal dial thermometers, recording thermometers, and fever thermometers if they can be had. Discuss the making of a mercury thermometer. Have each child in the group draw a diagram of a thermometer as the various steps in the making of a mercury thermometer are described. Illustrate the dis-

cussion by heating a piece of soft glass tubing and drawing it out into a fine tube and by blowing a bulb at the end of a piece of soft glass tubing. On the diagram mark only the temperatures which it is worth while for the children to remember: freezing temperature, boiling temperature, desirable room temperature, normal temperature of the body, and perhaps a few others.

Show the class how to write temperatures of below zero. Write a list of temperatures on the board. Ask someone to underline the highest temperature; the lowest. As a rule, there is no difficulty in such an assignment unless some of the temperatures are below zero.

Ask the class to tell ways in which they have seen thermometers used. Make on the board a list of uses of the thermometer as the class suggests them.

In the course of the unit, reading material should be provided to help check the conclusions at which the class arrives and to supplement the children's first hand experiences. Study exercises should be provided, and optional work should be planned for the faster workers. Some type of concluding exercise should be given.

To some readers certain of the suggestions which have been given may seem to complicate the content of the unit needlessly. For example, to some readers it will doubtless seem unnecessary to introduce the Centigrade scale, in view of the fact that the children studying the material are only in the intermediate grades. The author agrees that in some situations the matter of different scales might well be omitted. In other situations, the Centigrade and Fahrenheit scales should certainly be discussed. In the fourth grade class with which the author last handled the unit, there were several children whose fathers and mothers were scientists and who were more or less familiar with the equipment of science laboratories. When they began examining the thermometers in the laboratories, they found that most of them were marked with the Centigrade scale. One boy in the group had lived for a time in Australia, another in India; both had used thermometers with Centigrade markings, although they did not understand about the two scales. One boy brought to class a big catalog of scientific apparatus, and, of course, the catalog listed thermometers marked with different scales. Always the experiences which the members of a class have had should be considered in the determining of the subject

content of a unit. Any science teacher should feel free to modify any unit so that it will fit as well as possible the class to which it is being presented.

THE CONSTRUCTION OF A SIMPLE OSCILLOGRAPH

By Herbert Ott and Saul Geffner
Grover Cleveland High School, Queens, New York

The construction of the oscillograph was undertaken by Herbert Ott, a student at Grover Cleveland High School. This device is one of the many projects undertaken by students and was demonstrated at the Children's Science Fair held at the Museum of Natural History in New York City in April, 1935.

An oscillograph is an instrument which converts audio signals into visible wave forms which correspond to the original audio signal. The main parts of this instrument are the microphone, the amplification unit, the receiver, a revolving mirror run by a motor and finally a point source of light. The microphone may be of any type; the one used in this set-up was the ordinary carbon microphone. It is probable that better results may be obtained with condenser microphones.

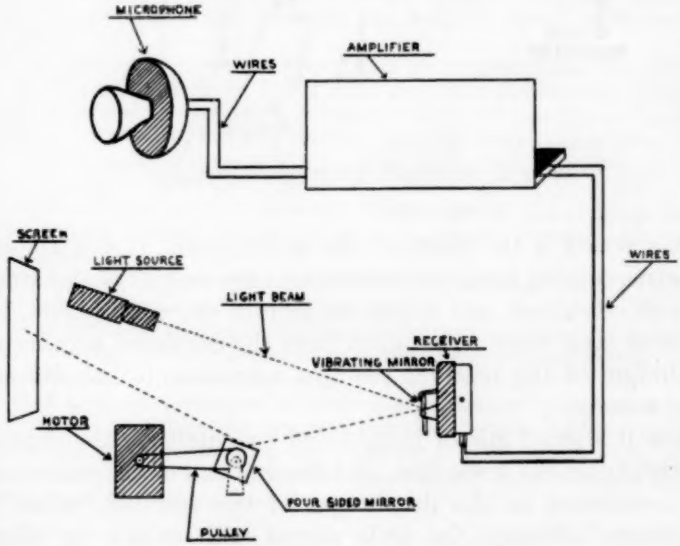

Fig. 1. Picture Diagram of Oscillograph.

The amplification used was of the "push-pull" type. Two battery type tubes were used namely a 219 and a 230. The power supply consisted of a "B" battery eliminator which supplied 180 volts to the plates of the tubes. The 2 volt filament supply was gotten from two Number 6 one-and-a-half volt dry cells in series with a ten ohm rheostat. Note the circuit diagram reproduced elsewhere in this report, Fig. 2.

The construction of the receiver represents an ingenious scheme. When you hold the ordinary telephone receiver to the ear, voice sounds are reproduced corresponding to those spoken into the transmitter. The presence of an electro-magnet in the receiver attracts and repels the iron diaphragm in the receiver according to the feeble incoming electric currents. These currents are pulsating due to the increase or decrease in resistance as offered by the carbon particles in the microphone.

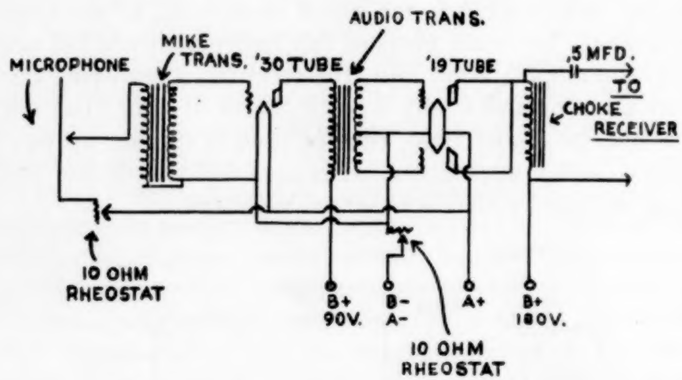

FIG. 2. Schematic Diagram of Amplifier.

This action is the heart of the oscillograph. If you connect the wires coming from the earphone to the output of the amplifier just described, and if you speak into the microphone, you will hear your voice reproduced from the earphone because the diaphragm of the receiver vibrates according to the different voice sounds.

Now if a small mirror is balanced delicately on the cover of the earphone like a see-saw, and the one end of the mirror see-saw connected to the diaphragm of the receiver, when the diaphragm vibrates, the little mirror will see-saw or vibrate back and forth on its pivot correspondingly.

Note the cross-section diagram, Fig. 1. The function of the

mirror is to reflect a spot of light which is focused on the mirror to a screen, so that when the mirror vibrates, the spot on the screen will also vibrate correspondingly. But this would not produce a wave form. Therefore, it is necessary to reflect the spot of light from the small mirror to a revolving four-sided mirror. The latter mirror simply stretches the vibration so that a wave form is produced.

Of course, this student-made oscillograph does not compare with products of the Cathode Ray type. It responds only feebly to high frequencies, but can be used in a physics class to demonstrate the various lower sound frequencies. The total cost is less than three dollars.

THE FUNCTION OF LABORATORY WORK IN ELEMENTARY CHEMISTRY COURSES

By H. I. SCHLESINGER
University of Chicago

The necessity of decreasing the cost of education and the trend toward making the last two years of high school and the first two years of college work a period of "general education" have brought to the forefront of discussion the place of laboratory work, as contrasted with lecture demonstration, in high school and college science courses. At the same time there has developed widespread dissatisfaction with the results of laboratory instruction.

The author has become convinced that the questions and the dissatisfaction have arisen because, in the rapid growth in the amount of subject matter presented to beginning students and in the number of students registered for work in science, the fundamental objectives of laboratory instruction have been neglected or entirely overlooked. A restudy of these objectives will, in his opinion, show:

1. That lecture demonstrations and experiments by the students themselves perform entirely different functions and are therefore not alternative procedures
2. That, correctly conceived, laboratory work has an extremely valuable contribution to make to "general education."
3. That the fundamental objectives are identical in all beginning science courses, whether they are intended as a part of "general education" or as an introduction to professional work.
4. That a return to the real objectives of laboratory work will require new types of laboratory exercises and directions, whose development will demand much effort, thought, and ingenuity. Cooperation of a group interested in the problem will be the quickest and most effective way of accomplishing the desired result.

[This is an abstract of a paper read at the New York meeting of the American Chemical Society, Division of Chemical Education, April 25, 1935.—ED.]

BUSINESS ARITHMETIC FOR THE HIGH SCHOOL

By H. E. Stelson
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In any consideration on a subject of this kind, it would seem fitting at the outset to inquire just what is a course in Business Arithmetic and just how does it fit into the high school curriculum. There are a number of titles which are used to describe this course. Commercial Arithmetic is commonly used. Many of the older texts were called Commercial Arithmetics. The newer texts do not use this name for the probable reason that the authors found it too restrictive, the subject containing topics not pertaining directly to commerce or the exchange of merchandise.

Recent texts have favored some variation of the term Business Arithmetic. A choice of four of the very recent texts by the most prominent publishers have the following titles: *The Arithmetic of Business, Modern Business Arithmetic, Business Mathematics* and *Social Business Arithmetic*. An examination of these books does not show any great variation of contents. In general they contain what might be termed the traditional course in Business Arithmetic. If there is no departure from traditional material, there would seem to be no good reason to denote a text as modern or use the somewhat more elite word mathematics which is in reality less descriptive of this type of work, which is Arithmetic. Social Business Arithmetic suggests a departure which might well be welcomed. A study of the contents and presentation of this particular book does not seem to warrant the additional name social.

But why call a course a Business Arithmetic? What is there about a Business Arithmetic wherein it differs from any other Arithmetic? While a common conception might be that a Business Arithmetic includes calculations peculiar to trades or industries, the term business is exceedingly broad and has included almost any topic an author desires to include in an Arithmetic. The dictionary states that a business is that which occupies one, the right or occasion of making oneself busy. By this definition a Business Arithmetic might represent almost any type of arithmetical effort.

An examination of present texts may give a current expression of what is meant by Business Arithmetic. It may be just as tenable and perhaps more desirable to give other interpretations

to this term business. In fact, it is the purpose of this paper to consider a type of Business Arithmetic which differs very largely from the so-called traditional Business Arithmetic, but which may well be called a Business Arithmetic, according to reasons which will be presented later in this paper.

It might be well to consider just what is traditional Business Arithmetic as it is presented in the majority of texts at the present time.

This subject seems to have been influenced in large measure in its origin by schools of business. Many students attending these schools had a very poor foundation in Arithmetic which was often due to meager schooling. These business school students needed training in the fundamentals of Arithmetic and such applications as office help might need. Adult evening classes have largely been of the same character. Business Arithmetic as it was first outlined may have been the most profitable course for schools of this type, but it is the purpose of this paper to consider Business Arithmetic as a High School subject. The introduction of the Business School Arithmetic into high school has served a two-fold purpose; first, to serve as a subject offered by the commercial department which was a training for clerical positions; and second, as a filler for those high school freshmen incapable of studying Algebra. It is this second role which has debased the reputation of the subject until it is often known as a dumbbell subject. It is probable that the apparent downfall of Business Arithmetic may be blamed in part to poor teaching. Mr. Nathaniel Altholz, Director of Commercial Education of New York City makes the following statement on page 84 of the Eastern Commercial Teachers Association, 1931. "It is doubtful whether there is any service commercial teacher training institutions can perform that is more imperative than that of meeting this serious deficiency of prospective commercial teachers in the content and the method of teaching business mathematics." The teacher of Business Arithmetic has not been chosen on the basis of a broad understanding of the application of the subject. Too frequently the teacher of business subjects has had little more than a knowledge of elementary bookkeeping and arithmetic, a smattering of stenography and the ability to write artistically.

While the teaching of this course is of great importance, it is the purpose of this paper to discuss the subject matter for this course. It has already been mentioned that the origin of

this course caused a great deal of emphasis to be placed on fundamentals. Now to what extent is Business Arithmetic applied, and to what extent is it pure or abstract Arithmetic? To what extent is it Business Arithmetic?

Practically all texts emphasize the need of drill and practice in the fundamental operations, and fractions, both common and decimal. This is generally stated as the first objective in Business Arithmetics. The usual book starts with a presentation of the four fundamental operations, common and decimal fractions and percentage. Many books contain such topics from abstract arithmetic as factoring numbers, greatest common factor, least common multiple, denominate numbers, the metric system, etc.

While there is no dispute on the question of importance of the fundamentals of Arithmetic, there does arise the question of the advisability of teaching these topics after the pupil has had Arithmetic all through the grades. The principal arguments which may be advanced for the reteaching of these fundamentals of Arithmetic are, (1) the constant complaint of business men and higher schools that graduates of elementary schools are deficient in performing the simple operations of Arithmetic, and (2) this deficiency tends to hamper the teacher of those business subjects such as bookkeeping and accounting which involve arithmetical operations. Our commercial texts realizing this deficiency, take the attitude that the way to supply the deficiency is to give more work in Arithmetic. If 8 years of a study are not enough to turn out efficient students perhaps one or two extra years in the high school will repair the deficiency. Instead of examining where the shoe pinches, whence the failure in the elementary school—they serenely pursue their own way, pretty much along the lines of the teacher in the elementary school. Many Business Arithmetics contain more abstract arithmetic than do the grade school arithmetics. In behalf of the elementary schools it may be said that they are improving their course in arithmetic. On the other hand, the teacher in the secondary school must face the situation as he finds it and study the best way to supply some of the deficiencies.

This sense of repetition of grade school work stifles the interest and effort of the learner. Try to teach a high school boy something he thinks he already knows! Repetition by drill is usually a waste of time. It is seldom that anyone improves radically his style of penmanship, his use of gram-

mar or his technique of arithmetic after 12 years of age.

It is not advisable to require the student to wade through unencouraging abstract material when he could start with applications.

The pupil will be activated to greater effort if instead of following the conventional routine of teaching the four fundamental processes with whole numbers, then with common fractions, then with decimals and finally with percentages, we call upon the pupil to apply his arithmetical skills at once to applied problems. If the pupil finds that he is deficient in any process, he will be more ready to concentrate on the formal work that the teacher supplies. Apathy yields to interest and purposive self application supersedes drudgery when the work is motivated. The applications themselves furnish a great deal of drill in the fundamental processes but the formality of drill as such is avoided.

The inclusion of so much fundamentals in texts and the stress on drill has caused authors to try to make their texts a complete treatment of arithmetic, starting with the very simplest exercises. I observed a second grade boy work out the first five pages of a Business Arithmetic. The exercises of the average Business Arithmetic are too easy. While they may keep the slow pupils occupied, they are in the main too easy to challenge the mind of the brighter pupils.

Since Business Arithmetic has purposed to train the pupils for office help, it has placed a great deal of stress upon speed of calculation. Rapidity is without doubt a valuable asset in a business office. It would seem more important, however, for the pupils to have a broad understanding of the subject. Let them develop the speed necessary for the peculiar type of operation after they engage in a trade. To aid in this rapidity of operations, Business Arithmetics have spent a great deal of time explaining short cuts in multiplication and division. These so-called short cuts, which are abstract arithmetic, have received such emphasis that many people have associated this with the sole object of the course. If you asked a student what he had learned in a course in Business Arithmetic he would reply, "I learned some short cuts." As a matter of fact that while these short cuts may be valuable, they are very seldom used. It is doubtful if even the teachers themselves make any use of these trick methods. It is very seldom that a college student will divide by four instead of multiplying by 25. No matter how

carefully he has been taught these short cut methods he soon reverts to the customary method he has been taught throughout the grades. The need of speed in calculation has been replaced in many cases by calculating and adding machines. If the purpose of Business Arithmetic is vocational in the sense of trade training, it would seem advisable to include some instruction in the use of calculating machines.

Furthermore, even if speed is acquired in a peculiar type of operation, the need for such an operation may be discarded by a change of business customs or a new type of machine.

Finally it may be said that the ability to understand and do should be considered paramount to the speed of doing.

The role of the fundamentals or of abstract arithmetic in the traditional course in Business Arithmetic has already been discussed. There remains a consideration of the nature and manner of presenting the applications.

This leads us again to a consideration and reevaluation of the objectives of Business Arithmetic. For what purpose are the applications presented? Business Arithmetic is commonly called a vocational subject. This word vocation needs explanation. One writer in the third yearbook of the Eastern Commercial Teachers Association writes on the topic of vocationalizing Business Arithmetic; the thesis being on the use of machines in study of Business Arithmetic. This merely illustrates the ambiguity of the word. Professor Paul S. Lomax, professor of Commercial Education in the New York University School of Education gives the following definition on page 22 of his book, *Commercial Teaching Problems:* "Vocational education should equip the individual to secure a livelihood for himself and those dependent on him, to serve society well through his vocation, to maintain the right relationship towards his fellow workers and society and as far as possible, to find in that vocation his own best development." Only the first part of this definition is commonly considered—to secure a livelihood for an individual.

The Los Angeles High School Commercial Syllabus, 1925, gives the following as aims to be accomplished in Business Arithmetic: The ability to use the knowledge of advertising in a practical way, to buy wisely, to act as receiving and invoice clerk, stock clerk, billing clerk, to take an inventory efficiently, to audit books of account, to perform the duties of a cashier, to make up a bank deposit and handle money, checks and other

cash items efficiently, to apply the knowledge of typewriting to practical office work, to apply the knowledge of shorthand to practical office work, to use the telephone properly, to operate the calculating machines of an office, to act as clerical worker in a business office, and to properly file letters, cards, and business papers.

The following may be quoted from Professor L. S. Lyon of the University of Chicago in his book *Education for Business*, page 407: "The commercial course has never clearly allied itself with the traditional purposes of the American high school. There has been an attachment but not a coalescence. The traditional courses of the high school have been organized into various groups under various heads but always poor as the accomplishment may have been—the high school function has been conceived as one of socialization. In this aim the high school commercial course has not liberally participated. Bound by traditions and encouraged by circumstances, it has adhered to its narrow utilitarian ends."

It is not the purpose of this paper to challenge the value of the commercial course in high school or of commercial education. The aims of the Los Angeles high school and this quotation of Professor Lyon have been given to point out how Business Arithmetic has been conceived as a subject which purposed chiefly to give trade training. What part of these aims of Commercial Education that Business Arithmetic purposes to supply will now be considered. Just what kind of applications do the textbooks present?

The following quotation may be taken from Rosenberg's Business Mathematics, "The content of the text has been limited to such topics as are of direct commercial value, and the practices and techniques adopted are those that prevail on the job. Business Arithmetic is a foundation subject for most of the clerical positions in an office. Much of the work in the business office consists of making arithmetical computations of various kinds. This course in applied business arithmetic develops the ability to make them correctly and speedily." This statement is representative of most texts in this subject. The following topics are given in a Business Arithmetic by Finney and Brown and are the ones usually presented: Trade and cash discount, transportation charges, cost of a manufactured article, selling the manufactured article, merchant's profit and loss, selling of merchandise, consignments and shipments, produce exchanges,

wages, fire insurance, depreciation, inventories, business statements, simple and compound interest, savings bank accounts, domestic and foreign exchange, sole proprietorship, partnership, corporations, taxes, life insurance.

This list of topics appears to be so broad and extensive in scope that if a knowledge of them is acquired it should warrant a place as a valuable course in the high school curriculum. But this is just the point where the results have been unfruitful. The pupils have not been presented with any thorough or satisfactory knowledge of any of these subjects. Ask the student what he knows about produce exchanges, foreign exchange, life insurance or taxes. The Business Arithmetics have merely given a smattering of problems that occur in these topics. First the pupil is presented with one type of business problem and then without explanation a second type is presented. The basis for grouping has been that of fundamentals not of applications, i.e., problems of all types of business are presented under the common heading, *per cent*. No adequate explanation has been given of the topics which give rise to the problems. The course has been one of Arithmetic and not business. The student is not particularly interested in working a problem in depreciation or stocks unless he knows something about depreciation or stocks. That book is best both from the standpoint of interest and information which presents carefully the applications giving rise to the problems. If properly conceived and planned the applications can be made a medium through which the pupil's skills can be perfected without making him arithmetic conscious. This should be the secret of improving the student's deficiencies in fundamentals. It is a sound and modern educational procedure.

It has been pointed out that the basis for selecting the topics has been largely that of their usefulness in clerical occupations or trade training. These topics have not been explained except such as was necessary to enable the pupil to work the extracted exercises.

May we purpose to select the applications on an entirely different basis; those topics will be presented which an individual finds to be the most valuable in his own personal business experiences. While such a Business Arithmetic may no longer prepare the student for a clerkship, it should give him a training in such business as the student will encounter in life.

Society is concerned only about that course in Business

Arithmetic which is of greatest social worth to most school boys and girls in their business practices. As Professor Lyon has said, this is the chief function of the high school. Can we socially justify our present commercial arithmetic course as is commonly found in our high schools? Is a commercial arithmetic course socially justified which only enables the student to perform clerical duties? Of all the great variety of experiences which characterize business endeavor have we included the ones that are of most consequence to American youth? In our present economic situation social business training is a prime requisite of citizenship. Is any business course socially justified if it fails to help correct the present status in which 94 men out of every 100 who arrive at age 60 are penniless? This basis which we have selected for the selection of topics is not a change from vocational or occupational education to the so-called academic training. The high school needs to train for occupational efficiency, but it is not the function of the high school to train for a particular type of work. That is the function of the Business School. In applying this basis for selecting the topics, let us consider how the average man spends his average earnings, $1600 per year. According to the statistical abstract for 1933 we find the following facts regarding the expenses of the people of the United States. $160 or 10% of the income is spent for insurance; another 10% is spent for taxes. Outside of the necessary expenses of the family budget such as food, shelter, clothing and operating expenses, taxes and insurance receive the greatest per cent of the income.

Life insurance has increased 1000% from 1900 to 1928. It is estimated that one half of all the men, women and children in the United States now carry some type of Life Insurance. It is of utmost importance that boys and girls have a knowledge such that they will be able to purchase insurance wisely. It is doubtful if a majority of students who enter college can tell the difference between an ordinary life policy and an endowment policy. Just as in any other financial matter, it behooves the individual to know and to do his own thinking in purchasing insurance. May we quote from a pamphlet put out by the Carnegie Foundation: Some misapprehensions touching life insurance: "The Agent is often innocent of any great knowledge of the subject, and who, however good his intentions, is financially interested in the form of policy to be taken." What rules can be given for the amount and type of insurance that a per-

son should buy? To what extent is insurance investment and to what extent protection? What causes the death of the average person? What is his chance of dying from accident? How may an insurance claim be settled? For what type of people is a life annuity advisable? Where and how does the insurance company invest its money? These are some of the questions to which a study of insurance should help the student to formulate an answer. The student should know the basic ideas of fire, autmobile and health insurance. A need for this type of knowledge is encountered by almost every individual. Finally it may be said that the future of insurance for good or bad is dependent on what use and attitude the people take regarding it. It is certain that a knowledge of insurance will tend to check abuses that might easily be foisted on unsuspecting peoples.

During the last few years the people of this country have become conscious of the cost of operating the government of the country. Besides the work of relief and material expenses of the government it may be estimated that the income of one eighth of the people comes directly from the government. It would seem hardly necessary to point out that an aim of any course of this type should be to discuss the collection and distribution of taxes.

Stocks and bonds are investments in which a large per cent of the people are directly interested. It was estimated that over three million people were actively trading on the stock market in 1929 and that there are probably a million playing the market at the present time. Newspapers publish a daily financial page in response to a general interest in this type of investment. This information should be offered in a business arithmetic course. The pupil should learn the way of buying a bond, how to compute its yield and estimate its security.

The largest per cent of volume of business is carried on in and for the home. Business Arithmetics have failed to take note of this fact in the past. The proper management of personal and family finances should be of vital concern in the life of every individual. The principles of business practice are no less applicable to the home than to the office. The success of any individual in the world of business may often be forecasted by the manner in which he administers his personal finances. Real problems in food costs, renting and owning a home, improvements in a home, clothing cost, and overhead expenses should be considered. These problems need not be of the 2×4 type

found in the lower grades but should be more difficult problems in relative costs. Some of the elementary problems of dietetics, a knowledge of which may be useful to both cook and consumer will be a valuable addition to the section on food costs. Next in importance to a knowledge of those things wherein money is expended is the knowledge of the transactions involved in the expenditure. In this class of subjects are included: Installment buying and small loan companies, interest and discount, annuities, and the customary topics, percentage, commission, brokerage, trade and cash discount.

At the present time probably 85% of all automobiles, 80% of all furniture and washing machines and 25% of all jewelry may be estimated as selling on the installment plan. Whether you favor or oppose buying by this method, it must be recognized that this is an important feature of American business transactions. According to the Government statistics of 1931, agencies in the small loan field made loans of about 2½ billion to 14,350,000 borrowers. While some people may be included in this group more than once, these figures do point out the vast importance of the transactions to the people. The average family borrowed $84 from some loan agency in 1931.

While commercial banks still maintain an important place in money transactions, their value in effecting loans to private individuals has been largely usurped by small loan agencies, unlicensed lenders, pawnbrokers, finance companies and industrial banks. Of the figure quoted above, commercial banks loaned only 7.3%. It is no longer sufficient to study only the operation of commercial banks. They have in large measure lost their place as a loaning organization to the private individual. If the replacing organizations are less desirable, that is an economic fault of our present system which only concerted action of the people may remedy.

It would seem the part of wise economics for people to have at least an approximate idea of the interest rates they are paying in installment plans and to small loan agencies.

So far the topics we have presented have pertained to the use and expenditure of money.

Dr. Charles H. Judd, Dean, School of Education, University of Chicago, in Money, a Neglected Social Institution in Education pp. 3–7, September, 1933, says "The value of money, its meaning for social cooperation, and its place in the industrial

and governmental systems of the country are not included in the ordinary school curriculum.

If one regards education as a preparation for efficient living, it seems imperative that somewhere along the line there should be a vigorous attack on the difficult problem of teaching people something about money and how to use it. . . . It (the adequate teaching of money) is very much needed by a society that is in distress because of widespread and gross ignorance of economic principles among a people thoroughly drilled in arithmetic and bookkeeping."

James L. Palmer, Professor of Marketing, School of Business, University of Chicago, in The Extent to which Business Educates the Consumer, pp. 87–95, October, 1934, says "Business as we know it today has devised the most elaborate, most penetrating, and most inescapable system of education the world has ever seen. Its teachers are legion, for they include everyone involved in any form of sales promotional work. Its standards are primarily monetary. It does not concern itself with the intellectual standards of prospective students. Anyone with a dollar to spend is eligible. . . .

I recommend, therefore, particularly for our secondary schools, courses that teach the student how, when, where, and upon what to spend his money. These will be courses in the arts of advertising and merchandising, if you please, but their object will be to teach how to buy rather than how to sell."

Beyond those topics which pertain to spending money and those topics which pertain to transactions involving monies, three subsidiary topics may be presented which appear to be of sufficient importance to be placed in a Business Arithmetic course.

In tabulating and presenting any sort of numerical facts pertaining to business a certain amount of elementary statistical information is valuable. Such information may well be used in presenting the above topics mentioned.

The use of tables and the process of reading between the lines in a table, called interpolation, are worth while in reading the tables of insurance, interest and bonds.

Two important type formulas appear throughout the topics of Business Arithmetic. The formulas for commission, brokerage, taxation, simple interest, approximate yield on a bond, interest charge on an installment payment or loan, accrued interest on a bond and yield on a stock may all be considered as applications

of the formula base $\times$ rate = percentage where the first of two quantities to be compared is taken as the base. If the second quantity is taken as the base there results the class of formulas, simple discount, trade discount, cash discount, profit on retail merchandise and equivalent trade discount. A discussion of these formulas helps to unify the course and to generalize the operations. The topics which have been suggested may constitute a semester or a year course. May we once more state the objectives of this course.

There is a business side of every social institution: The home and its expenses, the church and its budget, the government and its taxes, the school and its cost of education; besides the operation of institutions as insurance and the stock or bond market. All social institutions, constituted as they are in a material world are fundamentally forms of business organizations that seek to make use of our social resources. Again, business as a social institution is rightly organized and managed only when business in its profit making so utilizes our social resources as to promote economic well-being. Finally, the school as a social institution is rightly organized when the school gratifies the wants of students in their whole life experiences in home, church, government, organized recreation and in business.

OBSERVATIONS OF A SCIENCE TEACHER

By Ross McConnehey

The driver with a small supply of gray matter must have a big auto horn.

Teachers who know little about the subject talk most.

If a pupil cannot solve a numerical problem involving a scientific principle, it is fair evidence that he does not comprehend its meaning.

Pickled cats and ripe fish are enough to drive any elementary student away from zoology.

It is easy to teach pupils how to solve numerical problems. It is difficult to teach physics without solving problems.

Some teachers try to teach science and forget all about its use in daily life.

One of the chief results of the no-home-work soft pedagogy in the grade and junior high schools is a let-the-teacher-do-the-work attitude in senior high school and college.

If a subject is properly presented some pupils cannot be prevented from doing home work.

The hardest job the principal gives me is to ask me to teach my pupils something I do not know myself.

If the schools of the country were given a sufficient number of teachers to do the work right, there would be a dearth of teachers rather than a surplus.

BLACK WIDOW SPIDER

By John Sarracino
Neodesha, Kansas

In the terrific heat of last summer, which proved somewhat unbearable to the Middle West, numerous black widow spiders made their appearance. Perhaps the heat was especially favorable for the existence of these creatures. Newspapers published accounts of individuals being bitten by the spider; however, little or no information was printed concerning its habits and activities. One wonders if much is known about this spider.

For purposes of observation, a black widow spider and her egg case were brought to the laboratory of the Neodesha High School, last September. They were placed in a quart jar and carefully observed by the writer. The mother spun a web before the eggs hatched. After hatching, the young cluttered the entire web. As days passed, the young dwindled in number so that by December only four remained alive. Whether or not the young are cannibalistic in nature was not determined. The mother certainly was not devoured by her young.

Rarely was the mother seen during the daytime. At night she would venture from her hiding place, which was the underside of the quart jar lid. Is she a nocturnal creature? Before the spider became acquainted with her observer, she would race to her hiding place whenever an attempt was made to handle the jar. The tapping of the table would frighten her. However, as time passed, even the gentle tapping of the jar would not disturb her. Sometimes the jar lid was unscrewed slightly, thereby twisting the web. As a result the spider would spring back and forth on her web. It appeared as though she were ready to leap if necessary.

One night a piece of Christmas candy was dropped into the jar. The spider fell from the web to the bottom of the jar, although the candy did not touch her whatsoever. The next morning Mrs. Black Widow Spider was at her usual hiding place. Was her act of the night before a feigning one? At no time was the adult seen on or near the candy and only one young ever appeared on it, probably consuming some of it.

One morning the adult spider was found dead at the bottom of the jar. It is hoped that the young, through being cared for and observed, will verify some of the above observations and will yield more information about the habits and activities of the black widow spider.

A HALF HOUR WITH A CHEMIST

By C. H. Stone
Brookline, Massachusetts

[Mr. Stone has found a way to demonstrate to all the pupils of his school that chemistry is a delightful subject. He has prepared and given many short lecture demonstrations to develop a school interest in the subject. Other teachers should try his plan. Of course some preparation is needed, but it will be worth the work required. We present here a specimen of his talks with an outline of the experiments required—Ed.]

The work carried on in a chemical laboratory is sometimes dirty, tiresome, and not especially attractive in character. The life of a chemist is by no means all beer and skittles. Some chemical preparations require the most careful attention and often the chemist must keep close watch over the process for hours. One preparation which I have in mind takes eight hours of close attention to the temperature in order that the chemical reactions shall take place in the proper way. Yet there are a large number of experiments which can be performed easily and quickly, and which are both interesting and valuable for the light they throw upon some point on which one may seek information. I have selected a few of these in the hope of interesting you this morning.

Here are six tall jars, each containing a colorless liquid, except the last one in which the liquid has a pinkish color. ($PbAc_2$, $CdCl_2$, $HgNO_3$, $AsCl_3$, $AgNO_3$, $CoCl_2$.) I now pour into each jar some of the colorless liquid in this beaker. You will notice that as I pour with my right hand the product formed in the jar is black; but if I pour with my left hand, the product is yellow. In the last jar, since I used both hands to pour with there is no product at all. I stir up the liquid with this glass rod and then we see that something happens. (Add H_2S, stir with rod dipped in NaOH.) (Exp. 1) This experiment illustrates the process of forming insoluble products and is called "precipitation" which every Latin shark present will recognize as coming from the Latin verb "Praecipitare" which means "to cast down." I suppose, however, that I do not need to explain that to such an intelligent audience as is here this morning.

I am now dropping a little of a dye called Congo Red into this tall jar of water and it is interesting to note the long red lines as the particles of the dye slowly fall through the water. As the process is slow I will hurry it up a little by stirring the liquid with this glass rod. (Stir with rod wet with con. HCl.)

Oh, how did that happen! It has all turned blue! Well, I suppose that spoils the experiment so I will turn the liquid out into this other jar. Now it has all turned red again. (Exp. 2)

Congo Red belongs to a class of substances which the chemist calls indicators because they indicate whether an acid or a base is present, turning one color in the presence of an acid and another color in the presence of a base. Can you figure out how the colors changed?

Now I call your attention to these three jars, each containing a liquid. ($KSCN$, $BaCl_2$, $K_4Fe(CN)_6$.) I will pour some of the colorless liquid in this beaker into each of the jars. Certainly this is a patriotic experiment! Red, white, and blue in the proper order, and all poured out of the same beaker. (Add $Fe(NH)_2$ $(SO_4.)_4$ (Exp. 3)

Chemists are often interested in the bleaching of cotton and wool. Here is a small skein of wool of a dark color. I will just lower this wool into a jar of colorless liquid and you see how quickly the wool is whitened. (Boil wool in $KMnO_4$.) The bleaching agent in this case is sulphurous acid. (Exp. 4)

Talking so much makes me thirsty and so I will pour out a drink of Grape Juice from this bottle and—Oh, I forgot the Volstead act. It will never do to have this around so I will just pour it into the jar in which the wool was bleached, and there we have disposed of our Grape Juice. (Exp. 5) It was really a solution of potassium permanganate.

Now let us see what will happen if we pour a bleached-out Grape Juice into this jar of Orangeade ($K_2Cr_2O_7$) which happens to be handy. Now that would be a good experiment for St. Patrick's Day, wouldn't it? (Exp. 6)

None of my drinks seems to prove very attractive so perhaps I had better stop now for a moment and take a chemical smoke. Did you ever try one? I'd walk a mile for a chemical smoke. Ah! They satisfy! This particular one is made by blowing concentrated ammonia through concentrated hydrochloric acid. (Exp. 7) You may be interested to know that this is one of the methods which may be used to make smoke screens in time of war.

Everybody knows about Sterno or canned heat. Let us see if we can make a little of it. Here are ten cubic centimeters of denatured alcohol and in this little beaker I have two cubic centimeters of a *saturated* solution of calcium acetate. I pour the alcohol into the beaker and in one minute it becomes solid.

You see I can turn the dish upside down and the alcohol stays in the dish. Let us cut out a piece of it and see if it will burn. Yes, there it goes! (Exp. 8) Solid alcohol is a form of chemical substance called colloidal, and colloids are in general very interesting to study and experiment with.

Here I have a dish of thick cream. I am going to add some vinegar to this cream. Now I stir it up with my fingers and pretty soon we find that our cream has turned into a ball of butter which I will wash in this tank of cold water. Now if we examine it, we find that it is not butter but rubber, and real rubber too. (Exp. 9) This creamy material is the milk of the rubber tree and is brought to this country in ships from the East Indies or from Brazil where the rubber trees grow on plantations or in the wild state. The milk is called "latex."

We can made a pretty good imitation of milk by pouring this water into this tall jar. It certainly looks like milk, doesn't it? Well, it is only bismuth oxychloride and it will disappear if I add a little con. HCl to it and stir. (Exp. 10)

When you stir sugar into your coffee in the morning, the sugar disappears and you say that it has dissolved. The chemist calls that a solution of sugar in coffee. Now some of these solutions are curious things. Here is one which you see is a perfectly colorless liquid. (NaAc) I am just going to touch the wet tip of my pencil to a little of a white powder and then touch the tip of the pencil to the surface of the liquid. You can see that the liquid is changing to a white solid and finally I can hold the tube bottom side up without anything running out. Also I notice that it gets hot as it solidifies. I wonder if water gives out heat when it freezes. Of course, *you* know whether it does or not but you might ask your Physics teacher just to find out if he knows too. (Exp. 11)

I wonder if any boys of your acquaintance frequently hang around outside the classroom door till the instant the bell rings and then slip in just barely on time? Probably you don't know any of that sort.

Well, some experiments are about like that. They do not come off promptly, but seem to want to take their own time about it. Here is one of that sort. I pour these two liquids (KIO_3 H_2SO_3) together in this tall jar containing a little starch paste. Nothing happens, or will happen for about twenty seconds, and then it will happen all at once. NOW! (Exp. 12)

Sometimes, though, the experiment goes off a little faster than that. Here is a little black powder spread on some filter paper tied over the mouth of a bottle. I just tickle the powder with a feather and you all hear what happens. You see the powder is just "tickled to death." The black powder is nitrogen iodide. (Exp. 13)

If you want a little wine all you have to do is to cover the mouth of a tube of this liquid with the thumb and then tip the tube bottom side up. It is very simple you see. I think Mr. Downey could do it as well as I can. There! You see how easy it is. Will you try one of the tubes, sir? Hold it just as I showed you and turn it over. Oh, you did not do it right! Let me show you. This is the way. Now I wonder why that did not work. Oh yes, I used the wrong hand, that was all. You see now it works beautifully. (Exp. 14)

But my time is up and I will stop now, hoping that you will come again some other day, and now I call your attention to this sheet of paper which is, as you see, perfectly blank. I will just dip the paper into a solution of ammonium hydroxide and then it says (Exp. 15)

THAT'S ALL.

EXPERIMENTS

Exp. 1. Six 50 ml graduates containing respectively dilute solutions of: lead acetate, cadmium chloride, mercurous nitrate, arsenic chloride, silver nitrate, and cobalt chloride. Add hydrogen sulphide solution to each. No precipitate with cobalt chloride, of course. Stir with rod which has been standing in a test tube containing sodium hydroxide solution.

Exp. 2. 250 ml graduate filled with water. A little solid Congo Red dye. Drop in the dye. After a moment stir with rod dipped in acid. Pour resulting blue liquid into another graduate containing sodium hydroxide enough to cause color change.

Exp. 3. Three graduates containing; potassium sulphocyanate sol., barium chloride sol. and potassium ferrocyanide sol. Add solution of ferric ammonium sulphate.

Exp. 4. Immerse skein of wool in potassium permanganate solution, remove and dry. Immerse the dark colored wool in a bath of sulphurous acid.

Exp. 5. Pour beaker of dilute potassium permanganate into sulphurous acid used in previous experiment.

Exp. 6. Pour the sulphurous acid into a dilute solution of potassium bichromate; it turns green.

Exp. 7. Blow con. ammonium hydroxide through con. HCl white ammonium chloride emerges.

Exp. 8. 10 ml denatured alcohol (95%) plus a little solid dye, if desired. 4 ml SATURATED calcium acetate solution. Pour together into a small beaker. A solid jelly forms.

Exp. 9. 20 ml latex in small beaker. Stir with finger and add acetic acid dilute.

Exp. 10. Pour bismuth chloride solution into water. Stir in con. HCl.

Exp. 11. Supersaturated solution of sodium acetate. Add one small crystal of solid sodium acetate. Feel of containing tube.

Exp. 12. One gram potassium iodate dissolved in 500 ml water. Saturate 10 ml water with SO_2 and dilute to 500 ml. Use 50 ml of each solution to which a little starch paste has been added. Time; about 20 sec.

Exp. 13. Prepare nitrogen iodide by treating one gram powdered iodine with 5 ml con. ammonium hydroxide. Remove portions of the powder to separate pieces of filter paper and let dry. CAUTION!

Exp. 14. Fill several test tubes half full of a solution of phenolphthalein. Moisten upper half of inside of each tube with sodium hydroxide solution and let dry. Don't let any of this run down into the liquid. Some of the tubes should be left untreated. For the one that doesn't work, have left thumb moistened with sodium hydroxide.

Exp. 15. Write any desired words on white paper with mercurous nitrate and dry. Dip paper in ammonium hydroxide.

LET'S DO AN EXPERIMENT

By Glenn O. Blough

Michigan State Normal College, Ypsilanti, Michigan

Just why children in the elementary grades should become excited at the sight of a test tube of red liquid that is being heated over a Bunsen Burner, may not be thoroughly understood. Perhaps it is because physical apparatus itself appeals to young children, perhaps frequent passing glimpses into a chemistry room are responsible, or perhaps the desire to manipulate the apparatus may be the reason for the ever present interest.

Be that as it may, it has been my experience that in a free activity period some one is bound to suggest: "Let's do an experiment." The exact nature of the experiment is usually of little consequence, but a table, finally loaded with sundry laboratory supplies gives evidence of an hour spent to the satisfaction of grade five.

When experiments are to become a part of the regular classroom procedure, however, the problem of how to effectively use this apparatus—interest becomes an important one to the elementary science teacher. To use an experiment as a part of a lesson, and to do so efficiently is in itself a problem demanding careful forethought and intelligent planning.

We, who are accustomed to using physical and chemical apparatus, often forget that pieces of apparatus which appear so simple to us, frequently seem complicated to children. Even the mere fact that thistle tubes can be shoved through holes in rub-

ber stoppers may be a revelation to the immature mind of a grade pupil. Our first step then, in developing an experiment in the elementary grades, may very profitably be an inspection of the materials to be used; thus clearing up any mysteries that may surround even the commonest piece of apparatus.

When the apparatus has been examined, perhaps the next step may be that of making sure that all children concerned know the reason for performing the experiment. A definite simple statement of the problem, written on the board may help to make sure that every child understands the purpose of the experiment, thus: To find out if air takes up room.

Having established the purpose, we may next proceed with the experiment, having first removed all unnecessary pieces of apparatus from the demonstration table. If the experiment is to be performed only once for the whole class, it is important that it be done in full view of everyone. It is likewise important that pupils be taught the necessity of making careful, accurate observations while the experiment is in progress, and that they realize the importance of not announcing a conclusion until they have given the matter careful consideration. Child participation whenever possible in experimenting helps to create interest. Simple experiments may be done by the pupils themselves. Those experimental procedures demanding more skill may be performed by the teacher with the aid of the pupils.

When the experiment has been performed and there has been sufficient time for observations, it is then time for reporting conclusions. Here the formation of theories becomes the chief activity of the group. The attitude that, "My theory is as good as anyone's else provided it represents my best thought," is an important one for children to cultivate. When this attitude prevails, more children participate whole-heartedly in the class discussion.

From the several theories given, the group may now select the one which it feels most nearly explains the problem, and then gather evidence to substantiate this theory. From this point on, the skillful handling of the class discussion is important. Proceeding in a logical order from the simple facts known at the beginning, to the final solution of the problem serves to give a clearer understanding to the members of the class than does a rambling discussion which is not progressive toward a definite goal. This development should unfold as does a story, facts revealing themselves one after the other in the

order which they are needed. Children subjected to this method of problem solving may eventually come to apply the method in their own thinking.

Having finally reached a conclusion which satisfactorily explains the original problem, time may profitably be spent in permitting students to ask any questions relating to the experiment to which they have not already received an answer. Giving time at the end of an experiment in this way sometimes affords opportunity for questions which would have been irrelevant if asked earlier in the hour.

It does not, however, seem reasonable to stop, merely with having explained the experiment. If science material is to be functional with the child and thus connected with situations in his environment he must see the connection between the two. For example, of what value is it for him to know that air occupies space if he never sees an application of the fact? It does then, seem worth while to bring into the discussion so-called "practical application problems" such as, "Why does the attendant at the filling station remove both of the caps from a gallon can when he is filling it with gasoline?" or "Why do you tip a bottle sidewise if you wish to fill it under water?"

Having finished the experiment and applied the results, there is still left the problem of recording these results. It is perhaps important in intermediate grades to write a simple account of the findings and to keep them for record. Sometimes a drawing of the apparatus accompanied by several clear statements about the drawing suffices as a science record.

The experiment, as a teaching tool in classes in elementary science is important, and, if well handled, can be made into a most stimulating and interesting method of teaching scientific truths. Using it poorly and without definite organization is wasted time; using it wisely and for well defined reason contributes materially to good science teaching.

SCOTLAND FIGHTS MUSKRATS, FEARING SPREAD AS INTRODUCED PEST

Scotland emphatically does not welcome one kind of American visitor—muskrats. These natives of the New World, which have become serious pests elsewhere in Europe, have lately appeared in Scotland, and strenuous efforts are being made to exterminate them before they become really numerous. The destruction of approximately 1,000 of the animals has been considered a matter for self-congratulation among Scottish conservationists.

OBJECTIVES IN HIGH SCHOOL BIOLOGY*

By Harry A. Cunningham
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PART II

In Part I, it has been suggested that our economic and social leaders have, during the last few years, given evidence of a lack of intelligent behavior; that the schools, although certainly somewhat responsible for this failure on the part of so many of our number that have essayed to be leaders, often fail to acknowledge this responsibility and have even sidestepped their responsibility by advocating doctrines that may not have a firm basis in fundamental biological science. It has been suggested further that biology furnishes much material which when properly selected, organized, and taught should make large contributions to the intelligent solution of many of our individual and social problems and that we, as biology teachers, should concern ourselves in giving the biology which is needed. It has also been suggested that there are objectives for biology teaching on various levels and that the attainment of these on the lower levels is necessary for the attainment of those on the higher. It has been pointed out that all of these objectives must contribute eventually to the intelligent reaction of people to individual and social problems; and that intelligent overt reactions to problematic situations must be preceded by many trial and error try-outs in the field of language. We have shown that the intelligent individual is the one who has a high correlation of success between his success in vicarious, or language, try-outs and his success in overt or actual try-outs. Finally it has been shown that the chief business of biology, as well as all education, is to equip individuals so that they will be able to make quickly all language try-outs to a situation; to experience by language the approximate results of each and thus be able to select the proper one for the actual trial. Let us proceed now to consider further the types of situations that are experienced; the language equipment needed to meet these situations successfully; and the types of activities needed to obtain this necessary language equipment in the field of biology.

Situations may be classified in different ways. For our pres-

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ent purposes it is helpful, I think, to classify situations in two ways: first, according to the proper method of meeting them and; second, according to the importance of their performance by all people. There are two chief kinds of situations if we classify situations according to methods of performing them, habitual and problematical. In most habitual situations the total stimulus experienced is about the same in its major aspects time after time and the reactions to typical situations of this kind soon become standardized. Standardized reactions to some habitual situations come after the situation is said to be understood. In other situations the habit is formed first and the reason for it is given later. The rationalization of habitual forms of behavior should be made sooner or later. Good examples of habitual situations are the various health situations habitual reactions to which are established in young children.

Problematic situations, on the other hand, have so many factors playing an important part that one seldom finds two sufficiently alike in their dominating factors to be able to form standardized responses. Young children are made responsible for the intelligent reaction to few or none of these problematical situations. But as children grow older they are required to take on the responsibility gradually for intelligent reaction to more and more of them. The proper method to use in deciding how to finally react to such problematical situations is the scientific method. This method should be set up early as an ideal and should be finally made habitual. The individual who does this effectively is intelligent. Some of the most important major life activities in connection with which problematic situations arise are: (1) family activities; (2) activities that have to do with population numbers; (3) activities in connection with growth and development; (4) activities in connection with protecting oneself against dangerous plants and animals; (5) activities in connection with producing and conserving useful plants and animals; and (6) activities in connection with the maintenance of life through proper nutrition.

In our consideration of the second classification of situations that has already been mentioned—situations grouped according to the importance of their performance by all people—we realize that some situations, or types of situations, must be met by all people by a certain type of behavior if the resulting activity is to contribute to life at its best and we as biologists must be concerned with these situations at the point where

biology must be used in meeting them successfully. Other situations must be met but may be met by one of a variety of equally good reactions. Leisure time situations are good examples of this kind. If one has leisure time to spend, he may spend it in activities that are ordinarily thought of as being in the field of biology, such as bird study and collecting and mounting leaves or insects, or he may spend it profitably in many other kinds of activities that are not usually considered as belonging to the field of biology. In response to this kind of leisure time situation, biologists may expect only their share as their subject competes with many others. It would be a mistake, therefore, to organize a required course around leisure time objectives only. Dependence has been placed, in the past, too much upon biology material of this type. This has been particularly true in the grade science work. We need not necessarily emphasize this leisure time biology less in the future but we should emphasize more the type of material that will be of use in problematical situations in connection with which, if we react intelligently, we must make use of biological information.

Most of us are very prone to overlook biological factors in many of our individual and social problematical situations. Tariffs are often revised so that protection is given to some industries and withheld from others without much, or any, consideration of the effect of the conditions under which laborers work in the industry upon their health. As a result of this lack of attention to, and evaluation of important biological factors in a social situation some countries protect by high tariffs industries in which the death rate is two or three times as high as it would normally be expected to be. Various problems relating to family activities are often passed upon with little or no consideration of various biological factors, such as: (1) the long period of infancy; (2) the fact that the mating impulse in man is not seasonal but continual; (3) the economic dependence of females during child bearing and rearing; and (4) the overlapping of periods of dependence of different children in a family. The question of population numbers is an important one today and is being dealt with by various nations in various ways; but in many cases it is very probably being dealt with without sufficient regard for certain biological factors which are very important if such problems are to be solved in a way that will make for life of a higher and still higher type in the future. It is very important at the present time to show in a

more forceful way than we have in the past the great importance of biology in meeting life situations successfully. This is of utmost importance if biology is to hold a respectable place in the school curriculum. What type of biology is of most use in the vicarious experiencing of the many possible reactions to a situation and the results of the reactions?

It is generally agreed, at present, that science principles, or generalizations, are of paramount importance. If we know that, as a general rule, insects with biting mouth parts may be killed by a poisonous insecticide and that insects with sucking mouth parts may generally be killed by a contact insecticide, we are better equipped to deal with insect pests than if our knowledge be confined entirely to specific facts. Even though we learn the specific insecticide to use against one hundred insect pests, the next insect pest that we meet may be a different one than any of the hundred that we have studied. If we are able to state in as definite a form as possible some of the relationships between various kinds of organisms; if we are able to state the influence of structure, on the one hand, and of environment, on the other, upon behavior; if we are able to understand the various influences of the physical factors of the environment upon living organisms, we are much better able to use science for predictive purposes. It might be pointed out in passing, that generalizations, in order to be of actual help in the solution of our problems must be fairly specific and not too large. The value of such a generalization as "there are many interrelations among living organisms," lies chiefly in that it designates a part of the field of biology into which, if we study, we may find more specific principles or generalizations, that may be helpful in the actual solution. Those who place too much emphasis upon the importance of very large generalizations are likely to be suspected of stopping short of the analysis of them that is necessary in order to find the more specific ones that are of actual use in the solution of specific problems. How do we get the understanding of principles, or generalizations?

We must experience the relationship between certain activities called causes and later activities called effects in a sufficient number of cases so that we feel fairly safe in assuming that the same effects will follow the same causes even when the total situation is somewhat different from any that have been experienced before. These experiences in order to be meaningful must be experienced directly and language symbols at-

tached to the activities so that they later may be quickly performed vicariously by means of language in the solution of problems, or experiences very similar must have been experienced directly, or the various elements or parts, of the total activity must have been experienced directly and language symbols attached to them so that the entire activity may be experienced vicariously by organizing the language symbols that have been attached to the various separate parts of the experience. This is generalization upon a high level. It is necessary, however, to generalize on various lower levels in learning.

In the formation of generalizations on the high level that has been referred to in the preceding paragraph, it is necessary to become acquainted with the various new objects or things. Words must be assigned to these new objects before these objects can be used in language activity when the objects, themselves, are not actually present. Groups of these objects when classified together must be given names. This is concept formation. The activities must be given words to stand for them if they are to be later experienced vicariously; and groups of activities when classified together, must be given language symbols. Here again we have concept formation. If we want to be very specific in our vicarious experiences we use words, called adjectives, to explain the details of objects and words, called adverbs, to describe more specifically the way or manner of performing the activities. When we consider the specific objects and activities; the kind of objects and the kind of activities, to which words must be assigned in order to be able later to experience these objects and activities vicariously, we have a basis for designating what direct experience is necessary and which of these direct experiences needs to be given in what is generally known as laboratory work. What, then, should be the nature of this direct experience which is later to make possible vicarious language experience in the solution of problems?

It is, of course, quite impossible and unnecessary to attempt to present students with all the total situations with which they will be presented in later life. New total situations are continually being presented that have never appeared in experience before. There are in fact never two situations even that are, in their many details, exactly alike. These total situations which we experience are made up of elements that are, comparatively speaking, fewer in number and common to many different situations. A relatively few elements appear in innumerably dif-

ferent combinations to make up the very great variety of problematical situations that we experience.

It seems to be the chief function of laboratory work to give direct experience like, or as nearly as possible like, the elements of the complex situations that we experience. It is possible to experience the specific parts of a complex activity in which principles or generalizations of biology are concerned and to understand the effect which the proper or improper performance of this particular part of the more complex total activity may have upon the total result of the entire reaction. There are many factors, that are not ordinarily considered to be within the field of biology at all, involved in the very complex activity of rearing a family. Many parts of this complex activity do come within the field of biology. The most important function of laboratory work is to show some of the most common and therefore the most important of the simpler activities which when properly performed and properly coordinated may be considered dominating factors in the larger activity. This gives a basis for deciding upon laboratory work necessary and the materials to select when a selection of materials is possible. The getting of these direct experiences, of small parts of more complicated activities, in laboratories is called laboratory experimental activities.

Such laboratory activities are performed as showing convection currents, osmosis, respiration, growth of bacteria, balancing of life in an aquarium, life histories of insects, etc. On the basis of the laboratory activities decided upon, the necessary equipment and supplies are selected. Under such procedure every piece of equipment is selected for a specific purpose or purposes. There are many possibilities for research at this point in the science program. Such a procedure is much more desirable than the plan in use at present, in many cases, by which courses are built and laboratory work determined in the light of certain rooms and equipment already provided. Under such a plan we have a reasonable basis for selecting such items as blotting paper, boards, bottles, broom sticks, cardboard, charts, cheese cloth, fruit jars, glass plates, glass tumblers, lampchimneys, nails, pans, paper, ring stands, rubber stoppers, soil, tin cans, wire, etc.

On the basis of the equipment and supplies used and the activities performed with them decision is made concerning: kinds of furniture; the laboratory services, such as electricity,

gas, hot and cold water, and compressed air; the size of rooms; distance of window sills from the floor and the distance of the tops of windows from the ceiling; and the kind of window shades. Finally there is a type of activity on a still lower and more elemental level.

In the performance of these laboratory activities, or experiments, certain more specific activities are carried on which are common to many different laboratory experiments and activities. Such activities as making things, bending glass tubing, boring holes in corks, cleaning things, collecting things, storing things, etc., are included here.

Thus, you see that there are objectives in the teaching of biology on various levels. Objectives are in reality always activities. These activities are of various degrees of complexity and they may be either vicarious, language, activities or overt activities. Since, if the activities are to contribute to life at its best, we must be concerned with the manner of the performance of activities at all of these various levels, it is necessary to recognize the importance of traits and ideals at each step in the process. The composite of the proper methods of performing each of the simpler activities that make up the larger one is the scientific method. The body of biological subject matter is not sacred and will change in the future as it has in the past as a result of more and more effective use of the scientific method. The method of solving problems, known as the scientific method is the thing about the whole procedure that is most important.

NATURE GUIDE SCHOOL ON WHEELS

Western Reserve University Summer Session announces a three-week educational tour through New York and New England beginning August 3 under the direction and personal supervision of Professor William Gould Vinal, biologist, nature guide, camp director, scout leader, author, and educator. A night in the clouds a mile high on top of Mt. Washington, a sail on Cape Cod Bay, a view of mighty Niagara, New England shrines, historic Boston, Plymouth Rock, Alleghany State Park, life in the mountains and on seashore. A thrill every foot of the way. Why go to Europe or anywhere else until you have seen America with Cap'n Bill? The "Travelogue Primer" describes the trip and gives full particulars. Total cost $100. Write to Professor William Gould Vinal, Western Reserve University, Cleveland, Ohio.

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A MECHANICAL MODEL FOR ILLUSTRATING ALTERNATING CURRENTS IN PARALLEL

BY J. J. COOP
Washington College, Chestertown, Maryland

The close relationships existing between mechanical and electrical oscillators are often used by writers and lecturers in explaining certain electrical phenomena. No lecture on self-inductance is complete without comparing it to the inertia of a mass. The action of a condenser is likened to that of a spring or an elastic membrane. Velocity is used to illustrate current. These resemblances have often been used by textbook writers in explaining and illustrating series resonance in alternating currents.

For example, if a coil whose self-inductance is L henries is connected in series with a condenser whose capacity is C farads the current in the circuit will become a maximum when the applied electromotive force has a frequency f, given by the equation

$$f = \frac{1}{2\pi\sqrt{LC}} \cdot \tag{1}$$

This is very similar to the equation for the frequency of a spring when loaded, or connected in series, with a mass M. For a spring the ratio of the stretch x to the applied force F is a constant, which we may designate by K. Then $K = x/F$. For this mechanical system the velocity becomes a maximum when the applied force has a frequency given by the equation

$$f = \frac{1}{2\pi\sqrt{MK}} \tag{2}$$

While the above considerations have been placed in many books the writer has yet to see in any book the extension of this analogy to the case of the coil and condenser connected in parallel. Perhaps it has been assumed as self evident.

The electromotive force necessary to send a given current through a coil is directly proportional to the frequency, whereas, the electromotive force required to produce a given current in a condenser is inversely proportional to the frequency. When a coil and condenser are connected in parallel as in Fig. 1(a) the voltage is the same for both, hence the current in the coil will

be large for low frequencies and small for high frequencies, while the opposite conditions prevail in the condenser. At some frequency the currents in the two branches will have the same value, and since they are in opposite phase the line current will be zero. This "resonant frequency" f is given by Eq. (1).

The above relations may be demonstrated by the apparatus shown in Fig. 1 (b). A rubber band K fastened rigidly at each end replaces the condenser and a mass M replaces the coil. In order to eliminate friction and to maintain a constant direction the mass is a block of wood mounted on four ball-bearing pulley wheels which run on two glass rods. The mass and rubber band are connected by the light, loose-jointed framework A. The pulsating force may be supplied by hand or by a mechanical

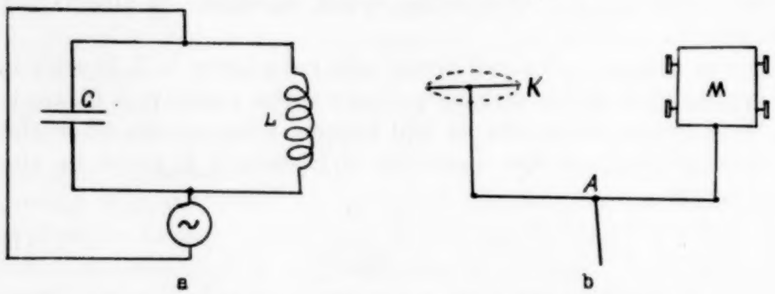

FIG. 1. (a) Electrical circuit; (b) Mechanical analogue.

vibrator. For slow vibrations the mass M will have relatively large displacements while the rubber band K remains nearly stationary. As the frequency is increased the displacements of the mass decrease while the displacements of the band increase. The "resonant frequency" at which both displacements are equal is so critical that the hand easily feels the sudden increase in resistance. At this point the displacements of both M and K may be one hundred times the displacement of the hand. Further increases in the frequency increase the displacements of the rubber band while those of the mass are reduced.

Since the terms in Eq. (2) are measurable the apparatus lends itself to quantitative as well as qualitative results. The resonant frequency may be determined by using a stop watch and checked against the theoretical value. Since the resonant frequency is the same for both series and parallel circuits another check on this frequency may be had by loading the rubber band K with the mass M and finding the period as before.

THE MEASURING OF TIME

By Eucebia Shuler
State Teachers College, Memphis, Tennessee

Sky Time Pieces—The Sun, Moon and Stars

The first time piece of the universe was the sun. This ancient sky clock has continued to run through all the ages and to serve as the main time piece for large periods of the day. All of our multiple and subdivisions of time have been based on the movement of the earth about the sun, and all of our instruments for measuring time have been constructed in accordance with the rotation of the earth about this luminous body.

Primitive man used only the center of our solar system as an instrument for indicating partitions of time, hence the measures had to be in terms of whole days—from sunrise to sunset. As society grew more complex it was necessary to keep appointments and to plan ahead; such essentials required some kind of indicator for periods longer than a single day. The daily position of light and shadow was no longer sufficient, and in addition, there were no sun shadows at night; hence man looked to the sky again and found a suitable time piece in the moon, the next most conspicuous heavenly body. It is significant that its name means "the measurer of time." Thus far nature had provided measures which served day and night if clouds did not hide them from view.

Society continued to grow more composite and people learned to combine with their neighbors for the sake of safety. In times of war, to keep from being surprised by the enemy, sentries had to keep watch while others slept. Our very word *watch* is derived from an old Anglo-Saxon word *waeccan* meaning *wake*. There had to be regular periods for changing sentries, but how was one to keep intervals of time at night? The stars were then called upon to contribute their part in the social problem.

Man progressed from the cave stage to the period in which he lived in rough stone or wood houses, cultivated the ground and raised cattle. As time went on he learned to read, write, and record events; but he continued for a long time to use the sun, moon, and stars as clocks. Time was divided roughly into days, moons, and seasons, the last mentioned probably having been determined by bird migration, budding trees and falling leaves.

Shadow Reckoning

It was observed that as the sun moved the shadows of peaks, cliffs and trees moved, and so did all shadows. Cliffs were probably the first *natural* sundials. Then sharp projections or points gave more clearly defined shadows which were easier to observe. Such knowledge suggested the use of a pole or stick stuck upright in the ground; the time of day was then marked on the ground by means of small stones. This was the beginning of the first artificial sundials and the smaller divisions of the time of day. The Egyptian obelisks and some of the pyramids are supposed by some modern travelers to have been designed and built as sundials. It has been found that their four sides stand exactly facing the four cardinal points of the compass. Some of the pyramids, so constructed, were used by crafty priests to impress the superstitious populace with fake prophesies in connection with the sun's periodic appearance upon certain parts of their temple idols, which were placed to catch the entering rays of the sun at a given time.[1] The Spaniards in their conquest of Peru found pillars of curious, costly workmanship set up in several places, by the meridian shadows of which their philosophers learned to determine the time of their equinoxes. These sundials were called *gnomons* (from gnonai, know) because the pointer cast a shadow by which we *know* the time of day and indeed the seasons as well. The oldest sundial (c. 1500 B.C.) extant may be found in the Berlin Museum.[2] It is an Egyptian piece composed of a long horizontal stick and a slightly elevated cross bar running perpendicular to the longer piece. In the morning the cross bar was turned to the east and in the afternoon to the west. The shadows were marked on the long bar to correspond to the six hours in the forenoon and afternoon respectively.

Later the gnomon was a stick placed perpendicular to the ground in the center of three concentric circles[3] so that at the end of every two hours the shadow passed from one circle to the other. This method was much more accurate than the placing of stones on the shadow lines because it partly took care of the variations of the shadows at different seasons of the year. It

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[1] Paula Moncrief, "Tennessee Possesses Unique Sundial, Declared Largest of Its Kind in World," *The Banner*, Nashville, Tenn., Nov. 13, 1932, 2.

[2] D. E. Smith, *History of Mathematics*, New York, Ginn and Co., 1923, 50. An interesting picture of this sundial may be found on page 50.

[3] W. W. Rouse Ball, *A Short Account of the History of Mathematics*, New York, The Macmillan Co. 1893, 18.

was noticed that this was still not entirely accurate, so the style or upright piece was put on a flat surface in the plane of the meridian and its edge was made to slope so that it formed with the horizon an angle equal to the latitude of the place, and consequently parallel to the axis of the earth. The modern sundials are constructed on this principle and serve as fairly accurate measures of time when the seasonal corrections are made.

Berosus (c. 250 B.C.), a Chaldean, used a hollow bowl in which were drawn lines; a small ball on a pointer cast the shadow in the bowl and indicated the time of day. From this came the idea of making the shadow move over a hollow space such as a walled courtyard, the light being let in by a small opening. In Isaiah, chapter 28, we find Isaiah sent by God to Hezekiah whose life He promises to lengthen by fifteen years, and He also promises to deliver his kingdom out of the hands of the Assyrians. This is to be the sign or assurance that the promises are to be kept: "Behold, I will bring again the shadow of the degrees, which is gone down in the sundial of Ahaz, ten degrees backward. So the sun returned ten degrees, by which degrees it was gone down." This sundial of Ahaz is supposed to have been a circular stairway which served the same purpose as the hollow bowl.

The ancients, who used the hemispherical dial plates, placed the radius in the direction of the north pole star and the shadow was then thrown on the hour lines—circular arcs—at regular intervals of 15°.

Up until a rather recent period the science of constructing sundials, under gnomonics, was an important part of mathematics courses. These sundials frequently had mottos on them. An interesting incident is told of a student who once went to Bacon for suggestions suitable for an inscription. Bacon was very busy and upon several attempts to get Bacon's attention the student received no response. Finally, Bacon, becoming impatient at repeated interruptions, said, "Sirrah, begone about your business,"[4] which retort the student used for his inscription.

Tennessee boasts of a unique sundial which is declared the largest in the world.[5] It is a vast cast stone structure which Mr. E. L. White built on his estate. It weighs more than ten tons.

[4] Harry C. Brearley, *Time Telling Through The Ages*, New York, Doubleday, Page and Co., 1919, 47.

[5] Moncrief, *op. cit.* 2.

The dial is an ellipse whose minor and major axes measure twenty-four and thirty feet respectively. The entire structure rests upon the ground. The pergola in the rear of the dial and the scrolled triangle of the twenty-five foot shadow bar strengthened by an inscribed ellipse, are so beautifully and artistically constructed that from a certain position the whole picture gives the effect of a large stringed instrument.

Scientific research revealed the fact that the sundial served as a surveyor's compass as well as a timepiece. The present day English and German miner's dial had a common origin in the portable sundials which were used as a cheap kind of watch or clock in Europe up to the beginning of the 19th century. Many of these dials, beautiful examples of engraving on brass or bronze, are now extant.[6] The surveyor discovered that by removing the gnomon from a portable sundial and by fitting a pair of sights or hooks in place of it he had a simple convenient appliance for his work. In some cases the dials were designed for both purposes, but in either case most of the dials were graduated in hours, whether for watches or compasses, thus definitely connecting the miner's dial with the sundial. Perhaps the term miner's *dial* from the Latin *dies*, a day, is itself suggestive of its origin.

The Water Clocks

It seems as if the clepsydra, or water clock, really was older than the sundial; certainly older than the perfected sundial. The oldest water clock dated back to 2679 B.C.[7] It was used in China in 1100 B.C., while shadow reckoning roughly comes between 2000 and 1000 B.C. In India the clepsydra consisted of a large brass bowl containing water and a smaller bowl which had holes in the bottom. The smaller bowl was set on top of the water and when it became full it was fished out by a boy, who was timekeeper, and who struck the hour. In China there is a water clock which some think is 3000 years old. It is composed of four copper jars partially built in masonry. The structure is stairlike and the jars are on successive steps. Water is poured into jar number one and through a small tube passes to the next lower jar and so on until it reaches jar number four in which there is a float, or bamboo stick, indicating the height of the water, hence the time of day. This method is supposed

[6] "Sundials Served Early Surveyors," *News and Courier*, Charleston, S. C., Nov. 24, 1930.

[7] James Arthur, *Time and Its Measurement*, Chicago (Reprinted from *Popular Mechanics Magazine*), 1909.

to eliminate much of the irregularity due to differences in the pressure of the water in a jar when full and nearly empty.

Clepsydra comes from two Greek words meaning "to steal water" or "thief of water."[8] Plato is said to have invented a very complicated clepsydra, but one of the simplest forms of this instrument was a short-necked earthenware globe, of known capacity, pierced at the bottom with several holes through which water escaped. There were many means devised to even the flow and the pressure under different temperatures. The clepsydra was used to set the limit on speeches in courts of justice. The hydraulic clock of Ctesibius (c. 150 B.C.) of Alexandria was constructed with a movement of water wheels that caused the gradual rise of a little figure holding a stick which pointed out the hours on an index attached to the machine. There was a clepsydra in the Tower of the Winds at Athens, the water supposedly being supplied by a cistern in the turret on the south side of the tower. The French Annals mention a water clock sent by Aaron, King of Persia, to Charlemagne about 807; it seemed to have borne some resemblance to modern clocks; it was of brass and showed the hours by twelve little brass balls which at the end of each hour fell upon a bell and sounded the time. There were also figures of twelve cavaliers which came out at the end of each hour through certain apertures in the side of the clock and shut them again.

Water clocks proved to be such unsatisfactory time pieces even at their best, that in their place about the third century at Alexandria there came the hourglass, sandglass or log glass as it was sometimes called when used to ascertain the speed of a ship. The hourglass consisted of two pear-shaped bulbs of glass united at their apices with a minute passage between them. A quantity of sand or sometimes mercury was enclosed in the bulbs and the size of the passage was so proportioned that the sand completely ran from one bulb to the other in the desired time. Formerly the hourglass was common in churches and even until the present a two-minute sandglass is used in the English House of Commons as a preliminary to a division. The glass is turned and while the sand is running the "division bells" are set in motion in every part of the building to give notice of voting. About the only other use of the sandglass now is for ornamentation or for timing eggs.

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[8] Brearley, *op. cit.*, 50.

Other Primitive Time Reckoners

There were a few other primitive methods of recording time such as: the slow burning of fuel by fire, burning ropes knotted at regular intervals used by the Chinese and Japanese, or cylinders of glue and sawdust marked in rings which slowly smoldered away. Alfred the Great in the ninth century is said to have invented a candle clock; it had six tapers twelve inches long, divided into twelfths or inches, and colored alternately black and white, three parts burning in one hour.[9]

Clocks and Watches

It may be said that the clepsydra was really the basis from which the modern clock grew, and from the clock the watch. *Clock* comes from the Saxon word *clugga* which means *bell* and many of the first clocks were striking instruments without hands or dials. The origin of the clock may be credited to the educated priesthood of the monasteries where much effort was spent improving time reckoners. Toward the end of the thirteenth century clocks were set up in several cathedrals in London. In the fourteenth century there were clocks really worthy of the name. They had one hand—the hour hand—at first; later the minute hand was added.

When Galileo was about seventeen years old he noticed that the lamp swinging in the Cathedral of Pisa made the sweep through a small arc in the same time as through a large arc. To test this discovery he timed it by his pulse; thus was discovered the principle of the pendulum which was later applied to the clock. The first pendulum clocks dated back to 1665. After that they passed through many improvements in the way of regulating the pendulum[10] in order to avoid variations due to changes in the weather and temperature. Pendulums were replaced by springs; improvements were made in the escapements and wheels until today we have a nearly perfect time keeper with very simple compact works.

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[9] Brearley, *op. cit.*, 62–63.

[10] The early American clocks of this type were made of wood. The industry developed in the Connecticut Valley about 1792. The first circular saw used in America was used in the making of wood clocks. Eli Terry, Silas Hoadley and Seth Thomas were names which were familiar in connection with the first clock factory (1807) in America. The clocks were of the long case type, or grandfather style. In the interest of sales long trips were made with quantities of these timekeepers. Only the movement or works were carried, the purchaser either built his own case or had some one to do it for him. Oftentimes no case was provided and the owner simply hung the works on the wall. In this instance it was called a "wag-on-the-wall" or a "wag-at-the-wall."

(Coleman, "Interest Is Revived in Early American Clocks," *The Banner*, Nashville, Tenn., June 5, 1932.)

Clocks at first were very large and cumbersome and not convenient instruments for one's pocket; hence the necessity for small clocks. However, the small clocks or watches were used more as ornaments than as timekeepers, for they kept a very poor record of passing hours. They were jeweled with double or triple cases of gold; they were thick and heavy with no crystals and only one hand; and they were made in a great variety of shapes such as balls, stars, ovals, and flowers. Among the first watches were those which were called "Nuremberg eggs" because they were shaped so much like an egg. A great variety of these odd watches can be seen at the Metropolitan Museum of New York City. The latest development along this line is the electric clock with which we are familiar.

A DEMONSTRATION OF THE INVERSE SQUARE LAW

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Most presentations of the inverse square law as applied to light take the form of a geometrical argument. While it is probably proper to look at this law as a consequence of three-dimensional space, still for the young student that lacks a certain realism. The following simple apparatus was devised and used to offset this reaction. The essential device is a rotating shutter to be placed in one of the two light paths of a photometer. This shutter consists of two identical pieces of black cardboard, each of which was cut from a circle into a butterfly shape having two 90° opaque segments oppositely spaced. These cards are placed face to face on the axis for an electrically-driven color wheel. Thus they can be adjusted to provide two equal openings between 0° and 90° or a total angular opening per revolution between 0° and 180°. This shutter is then made to rotate between one of the lights and the comparison device; and the positions of light, shutter, and comparison device remain fixed throughout the experiment. With the shutter at some arbitrary opening, the distance of the other light from the comparison device is adjusted for equal illumination. Then changing the angle of opening to one-half or twice the former angle necessitates the changing of the distance of the second light to four times or to one-fourth the former distance. There seems to be no difficulty in convincing the students that the intensity of the light coming upon the comparison device from the first light is proportional to the opening of the shutter. For lecture purposes the comparison device used is a 45° plaster of paris prism with the edge of the right angle toward the class.

CANARIES LEARN TO SING WITHOUT "TEACHING"

The beautiful and varied song of the roller canary can be developed by the young bird who has never been "trained" by an adult male songster. Twelve young roller canaries were hatched and raised in sound proof cages completely isolated from the song of any other bird except the unmusical modest chirps of the mother. Six of the eight males heard no rolls or tours of any kind until they produced them themselves. Two heard only the song of the other isolated young birds as they developed adult song.—From a report by Dr. Milton Metfessel.

MATHEMATICS IN THE INTEGRATED CURRICULUM

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As an aim in education, the integrated curriculum is a worthy one. Certainly, it is highly desirable that individuals after leaving school should be able intelligently to adjust themselves to life. We have attempted in the past to attain this objective by teaching separate subjects. This has been successful only for those who have a natural ability to adapt themselves anyway. We have tried correlations between fields of knowledge and parts of the same field in order to increase the possibility of the pupil making successful adjustments to life. In teaching by means of these correlations we still cling to the idea that one must study intensively certain topics in order to have a workable grasp of essentials in the particular field. Now comes the attempt to formulate the integrated curriculum. This third attempt to realize this worthy aim in education proposes a curriculum made up of units of work planned for a long period of time in which material from any field may be used.

Many teachers of mathematics have not yet graduated from the separate-subject aim and method. Many are still teaching algebra as one subject and geometry as another, and so on. The pupils *may* see certain relations between parts of the field, but it is by no means the general rule. It is much less likely that they see the connections between the field of mathematics and some other field. In other words, integration by this procedure is a rare thing. Some of our best teachers of mathematics have long been practicing *correlation* in their teaching. In fact, the very first experimenting in correlating subjects was done in mathematics. The idea was carried to science and out of it came the course in general science. Now, practically all schools have a course in general science. So-called "unified" courses in social science were next developed, and finally general mathematics was developed. Now, any junior high school in the country that makes any pretense of being progressive has a course in general mathematics. Also, senior high schools and colleges show a definite tendency in the direction of fusing or correlating mathematics. Those schools that *are* doing it have succeeded in having the students get the relations of various

parts of the field but not at the sacrifice of rigorous understanding and a connected whole.

Integration presumes a radically different type of school organization and curriculum than we now have. Not much progress has been made as yet in the use of the integrated curriculum. In senior high schools the integration of the curriculum has, in most cases, meant merely the use of an *integrated unit* of work, this unit making use of subject matter from two or three fields while other subjects are taught as usual. Some colleges have attempted "orientation" or "integration" courses.

Those who are now advocating the integrated curriculum are doing so because they realize that students leaving high school and even college are so poorly equipped to meet life situations in a world where life situations are so rapidly changing. They advocate the integrated curriculum because they are more interested in other aims of education than in the mere learning of subject matter. Some, perhaps, are going to the extreme when they claim they care nothing about what the pupil *knows* when he gets through. All admit, however, that learning to think clearly, learning to evaluate, development of personal qualities for social fitness, and the like are most important. Therefore, we should favor any change in organization or curriculum that will realize these values more fully.

I venture to predict, however, that the integrated curriculum that finally comes to pass will still allow for some differentiation of courses. That is, the curriculum will not be *entirely* integrated. We have recognized individual differences for years. We have realized the importance, and always will, of teaching so as to allow for these individual differences; so far as this is possible under any given set-up of school organization. I believe that the integrated curriculum will still allow certain highly specialized fields such as science and mathematics to conduct courses in these fields separate from the integrated courses. While mathematics will be making its contributions in all the integrated courses, it will still have an obligation to fulfill to those students whose capabilities particularly lie in the mathematics and science fields. In other words, I believe that mathematics is so tied up with human affairs that there *is* something of value in the field of mathematics for *all* students in the high school. The majority will realize these values from the integrated courses. The others must be permitted to follow the formal and more rigorous courses in mathematics (perhaps

fused or correlated courses), in order that they might get all there is in the field of mathematics for them. The mathematics preparation needed by students who are preparing for scientific and engineering lines cannot be obtained from these integrated courses. Frankly, I believe that the amount of mathematics that a student will get from these integrated courses will be very small. Certainly, it will not be at all adequate for those pupils in the senior high school who expect to specialize in science and engineering fields. The independent courses in mathematics in senior high school must remain even if the integrated courses are introduced, unless the mathematics now given in the senior high school is left for the college to do. It seems highly improbable that the colleges and universities will consider this desirable in face of the fact that they are constantly expecting more and more in the way of mathematical preparation from the high school. I think that it would be as definitely undemocratic to force *all* students in the high school to limit their knowledge of mathematics to that available in the integrated courses as it would be to require *all* students to take certain courses in formal mathematics. So, while the integrated courses will take care of the needs of the many so far as their mathematics is concerned, it will still remain necessary to teach independent courses in mathematics for the others, the ones on whom society depends for leadership in scientific endeavors.

There are certain limitations in the integrated curriculum that should be pointed out. Some of these would directly affect the teaching of mathematics, hence, should concern the teacher of mathematics very much. The success of the integrated method of teaching depends, as in all other methods, upon the type of teacher using the method. Suppose a teacher of an integrated course is inexperienced or knows very little about the subject of mathematics; he very probably will neglect it because he does not see its importance. I fear for "The Queen of the Sciences" when entrusted in the hands of such a teacher. Using teachers as we now have them, trained in one subject only, would certainly mean that some essentials would be neglected while others are over-stressed. Centering the entire curriculum around a social-science theme is very likely to neglect necessary skills, information, and appreciations in mathematics or in some other field, merely because the teacher does not know enough about these fields to see all significant rela-

tionships. The integrated curriculum presupposes a vast knowledge and sympathy of all fields on the part of administrators, directors, and teachers. That is, perhaps, the most serious fault in this method of teaching. Perhaps it is merely a matter of teacher-training. To take the ordinary teacher of social science, or any other subject, and hope that he will make up his deficiencies in the field of mathematics of which he knows so little and in which he has had no training, or expect his deficiencies to be met by the use of a teachers manual is to overlook entirely the importance of scholarship. The very nature of the subject of mathematics is such that it is impossible to acquire a teaching knowledge of it by such means. It takes study and practice over a long period of time. It is my sincere hope that the details of reorganizing the school curriculum for integrated courses will not be left to school people whose vision is so limited that the resulting curriculum is weighted in some particular direction. The interest of the pupil should be placed first. The place and importance of mathematics should not be overlooked. College teachers as well as high school teachers should be brought into the work of reconstruction of the secondary school curriculum.

Contributions of Mathematics to Integrated Courses

The ideas and suggestions contained in this part of the discussion are made with the assumption that independent courses in mathematics are to exist in the same curriculum with the integrated courses. I would prefer to spend my efforts in enriching our present mathematics courses, vitalizing the teaching, and increasing our correlation activities. However, I realize that the integration movement is upon us. I would suggest, in the light of certain limitations already mentioned, that we attempt to join two or three fields of knowledge into a unit, a unit covering perhaps one or two years of senior high school, and experiment with that for a few years. I think the science and mathematics could be two fields joined for purposes of such experimenting. There is something of value in these two fields for all students of high school, and for most students these values could be realized in a course of this kind. Ultimately, of course, I understand that in a truly integrated course no field of knowledge would be barred.

When the integrated courses have drawn from the field of

mathematics the contributions that mathematics can make, courses such as Practical Mathematics might be unnecessary. The objectives hoped to be realized by courses of this kind might be attained better in the integrated courses, providing they are conducted by teachers whose background, training, experience, and natural abilities qualify them as teachers of such a course. I have long felt that our high schools very effectively fulfill our obligations to those students specializing in mathematics, but we have been doing very little for the great majority who are not so specializing. Some teachers have made worthy attempts to teach "appreciation" of mathematics to "non-mathematically inclined" students found in classes with the capable students. I think it cannot be done this way. You can teach "appreciation" of mathematics to the mathematically inclined student by merely permitting him to work at the subject. His success begets interest, his increased interest compels him to investigate the field and study it more. The great majority, however, must be taught these values in a much different way. They will get glimpses of these values by being permitted to put to use the little knowledge of mathematics that they may have. Mathematics can be made to relate to other fields of knowledge by teaching its history and development. Reading material such as that published by the American Council on Education stimulates interest, because the material is put in easy form to read. Simple processes of mathematics as used in various activities of life can be taught by starting with what the pupil already knows. For the majority, those lacking a particular ability in mathematics, the values of mathematics and its social-economic importance can best be learned by its association with the learning in those fields in which the student *is* capable. If integrated courses will do these things for the non-mathematical minds, teachers of mathematics will be strongly in favor of integrated courses.

But while the beauty of a problem solved excites the admiration and yields a certain sort of satisfaction, it is after all the unsolved problem, the quest of the unknown, the struggle for the unattained, which is of most universal and most thrilling interest.—R. A. MILLIKAN. *Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays.*

Thermodynamics gives no support to the assumption that the universe is running down. Gain in entropy always means loss of information and nothing more.—G. N. LEWIS.

COMPARISON OF THE EFFECTIVENESS OF THE SINGLE LABORATORY PERIOD AND THE DOUBLE LABORATORY PERIOD IN HIGH SCHOOL CHEMISTRY

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Editor's Note:—We cannot refrain from calling attention to the author's statement of what he attempted to measure in his tests of the two divisions reported in this paper. In his own language, the tests were "designed to measure *retention of facts;* such as formulas, equations, names and facts stressed in the experiment, and laboratory procedure." In the very thorough report of the Committee on Examinations and Tests, of the Division of Chemical Education of the American Chemical Society we find that the retention of facts rates rather low among the important objectives listed by the large number of leading teachers of chemistry in our colleges and universities. "A *broad* and *genuine appreciation* and *understanding,* of the world in which they live" and "of what the developments of chemistry mean in modern social life, in industry and in national life" was given the leading place among the two pages of objectives listed in the report. Should we then, as teachers yield too complacently to the unworthy tendency to cut down on expenses for education at a time when billions are being spent for much less constructive projects? Our pupils may memorize a few facts in one laboratory period as well as in two but can we put across the higher educational objectives if we are pinched for time with individual pupils in the laboratory where some of our best work should be done?

Introduction

We are told that the single laboratory period is coming and that we may as well make preparation for it.[1] The purpose of this investigation is to determine the relative effectiveness of the single and the double laboratory period in high school Chemistry.

By way of preliminary investigation, three classes of about thirty-four students each were instructed to perform each experiment as quickly as possible without injury to their comprehension. This was left to the student's judgment.

Over a period of four weeks, eight experiments were done. The time taken by each student to finish his experiment was recorded at five-minute intervals ranging from forty to seventy-five minutes. Seven hundred nineteen cases were recorded. Of these, 275 or 38.2% of the experiments were performed in forty minutes. Fourteen and eight-tenths per cent more were performed in forty-five minutes, 19.6% more in fifty minutes,

[1] Curtis, Francis D. "Some effects of the Depression Upon the teaching of Science," School Science and Mathematics XXXIV (April, 1934), pp. 345–360.

7.9% more in fifty-five minutes, 10.5% more in sixty minutes, 3.6% more in sixty-five minutes, 1.8% more in seventy minutes, and 3.5% more in seventy-five minutes. Over 90% of the total number of experiments were completed in sixty minutes or less.

These data indicate the possibility of shortening the double laboratory period. On the basis of this hypothesis the investigation was continued through twenty more experiments.

Eight tests were given to cover twenty experiments.[2] Each test consisted of twenty-five blank space items designed to measure retention of facts such as formulas, equations, names and facts stressed in the experiment, and laboratory procedure. Each test item was scaled for difficulty on the basis of the percentage of correct answers.[3] Each test was first given as a pretest.

Nature of the Investigation

Three classes were used. One served as a control, the other two were paired with it. Individual student pairs were arranged on the basis of chronological age, previous semester grade in chemistry, I.Q., and classification. Tables I and II show a comparison of these factors for the three sections.

Table I

Factors Used in Pairing Section 1 with Section 2

	Mean			Classification	
	Chronological Age	Previous Sem. Grade Chemistry	I.Q.	11	12
Sec. 1	17 yr. 4 mo.	80.0	101.9	12	12
Sec. 2	17 yr. 7 mo.	82.5	100.7	9	15

The rotation method was used. At the close of the first group of ten experiments, section 1 and section 2 exchanged the length of time allowed for experiment. Section 2 and section 3 also exchanged the time factor.

Factors which could be construed as variables such as reading assignment, content and method of recitation, and writing of laboratory notes were considered in the same manner as the

[2] Raymond B. Brownlee and Others, *Laboratory Exercises in Chemistry*. New York: Allyn Bacon, 1932, pp. XII +304.

[3] Karl J. Holzinger, *Statistical Methods for Students in Education*, pp. 224–29. Boston: Ginn & Co., 1928.

corresponding factor in the paired section. The one variable factor was the time allowed for performing the experiment.

TABLE II

FACTORS USED IN PAIRING SECTION 2 WITH SECTION 3

	Mean			Classification	
	Chronological Age	Previous Sem. Grade Chemistry	I.Q.	11	12
Sec. 2	17 yr. 6 mo.	82.7	100.1	10	14
Sec. 3	17 yr. 8 mo.	82.7	99.8	17	7

Two tests in Table III favor the 2-period laboratory session and two tests favor the 1-period session. The differences are of such amount as to make a total of thirty-eight who favor the 2-period session and thirty-three who favor the 1-period session.

TABLE III

NUMBER OF INDIVIDUALS WHO FAVOR THE 1-PERIOD AND 2-PERIOD LABORATORY SESSION

	Test				
	1	2	3	4	Total
Sec. 1 (1-per.)	7	9	11	6	33
Sec. 2 (2-per.)	12	6	9	11	38

Two tests in Table IV favor the 2-period laboratory session and one favors the 1-period session. The differences are of such amount as to make a total of forty-three who favor the 2-period session and thirty-two who favor the 1-period session.

TABLE IV

NUMBER OF INDIVIDUALS WHO FAVOR THE 1-PERIOD AND 2-PERIOD LABORATORY SESSION

	Test				Total
	1	2	3	4	
Sec. 3 (1-Per.)	9	10	7	6	32
Sec. 2 (2-Per.)	9	9	13	12	43

Upon rotation of the time allowed for these two sections, three tests favor the 2-period session and one favors the 1-

period session. The differences are such as to make a total of thirty-seven who favor the 2-period session and thirty-three who favor the 1-period session.

TABLE V

NUMBER OF INDIVIDUALS WHO FAVOR THE 1-PERIOD AND 2-PERIOD LABORATORY SESSION

	Test				Total
	5	6	7	8	
Sec. 2 (1-Per.)	9	6	6	12	33
Sec. 1 (2-Per.)	12	9	9	7	37

Table VI shows that one test favors the 2-period session and three tests favor the 1-period session. Differences are such as to make a total of thirty-five who favor the 2-period session and thirty-eight who favor the 1-period session.

TABLE VI

NUMBER OF INDIVIDUALS WHO FAVOR THE 1-PERIOD AND 2-PERIOD LABORATORY SESSION

	Test				Total
	5	6	7	8	
Sec. 2 (1-Per.)	12	10	9	7	38
Sec. 3 (2-Per.)	9	8	7	11	35

Of the total number, 136 favor the 1-period laboratory session and 153 favor the 2-period laboratory session.

TABLE VII

COMPARISON OF THE MEAN DIFFERENCES BETWEEN THE PRE-TEST AND POST-TEST. SEC. 1 VS. SEC. 2

	Test				Total
	1	2	3	4	
Sec. 1 (1-Per.)	18.8	28.9	22.0	41.9	111.6
Sec. 2 (2-Per.)	24.1	20.5	24.3	44.3	113.2

Of the four tests, three favor the 2-period session and one favors the 1-period session. The total of the mean differences for the 2-period laboratory session is 113.2 and 111.6 for the 1-period session.

Table VIII shows that two tests favor the 2-period session. The total of the mean differences for the 2-period session is 103.1 and 99.5 for the 1-period session.

TABLE VIII

COMPARISON OF THE MEAN DIFFERENCES BETWEEN THE PRE-TEST AND POST-TEST. SEC. 3 VS. SEC. 2

	Test				Total
	1	2	3	4	
Sec. 3 (1-Per.)	22.3	28.6	17.2	31.4	99.5
Sec. 2 (2-Per.)	20.4	18.4	25.4	38.9	103.1

Tables IX and X show results after rotation of the time allowed for experimentation. Table IX shows that one test favors the 2-period session, two tests favor the 1-period session and two tests are tied. The total of the mean differences for the 2-period session is 113.9 and 114.8 for the 1-period session.

TABLE IX

COMPARISON OF THE MEAN DIFFERENCES BETWEEN THE PRE-TEST AND POST-TEST. SEC. 2 VS. SEC. 1

	Test				Total
	5	6	7	8	
Sec. 2 (1-Per.)	20.0	46.8	21.9	26.1	114.8
Sec. 1 (2-Per.)	32.1	36.0	19.7	26.1	113.9

Table X shows that three tests favor the 1-period session and one test favors the 2-period session. The total of the mean differences for the 2-period session is 103.4 and 118.8 for the 1-period session.

TABLE X

COMPARISON OF THE MEAN DIFFERENCES BETWEEN THE PRE-TEST AND POST-TEST. SEC. 2 VS. SEC. 3

	Test				Total
	5	6	7	8	
Sec. 2 (1-Per.)	29.2	41.2	23.6	24.8	118.8
Sec. 3 (2-Per.)	27.1	29.7	16.1	30.5	103.4

The total of the differences between the mean of the pre-test and the mean of the post-test for tests 5, 6, 7, and 8 is 444.7 for the 1-period session and 433.6 for the 2-period session. It was previously shown that 136 students favor the 1-period session and 153 favor the 2-period session. This evidence indicates a lack of superiority for either length of laboratory session.

Table XI shows that a total of 65 favor the 1-period session and 81 favor the 2-period session.

TABLE XI

NUMBER OF STUDENTS IN I.Q. GROUPS WHO FAVOR 1-PERIOD LABORATORY AND 2-PERIOD LABORATORY TESTS 1, 2, 3, 4

I.Q.	1-Per. Laboratory		2-Per. Laboratory	
	Sec. 3 (X)	Sec. 1 (Y)	Sec. 2 (Y)	Sec. 2 (X)
106–above	15	19	12	20
95–105	2	9	18	7
Below–94	14	6	8	16
Total	31	34	38	43

Table XII shows that a total of 71 favor the 1-period session and 71 favor the 2-period session. These data offer no evidence of the superiority of the double laboratory period. Neither is the single laboratory period shown to be superior. With equally good results for the 1-period session, school administrators would favor the shortened laboratory period as an economy measure. It is important to keep in mind that the tests used in this investigation were designed to measure increase in factual information which is not the only outcome of laboratory work. It is therefore desirable that further investigation be conducted on this problem.

TABLE XII

NUMBER OF STUDENTS IN I.Q. GROUPS WHO FAVOR 1-PERIOD LABORATORY AND 2-PERIOD LABORATORY TESTS 4, 5, 6, 7

I.Q.	1-Per. Laboratory		2-Per. Laboratory	
	Sec. 2 (X)	Sec. 2 (Y)	Sec. 1 (Y)	Sec. 3 (X)
106–above	14	10	17	17
95–105	7	16	10	3
Below–94	18	6	10	14
Total	39	32	37	34

Conclusions and Recommendations

1. The double laboratory period is not shown to be superior to the single laboratory period for classes consisting of high medium, and low I.Q. groups.
2. The rotation method indicates no advantage for the double laboratory period for high, medium, or low I.Q. groups.
3. The single laboratory period would result in considerable saving of time for both teacher and students. Other questions should be answered before its use becomes universal, viz:
   a. What effect does the length of laboratory practice have upon the understanding of principles?
   b. What effect does the length of laboratory period have upon the student's performance in the laboratory in more advanced courses?
   c. What experiments are suitable for the single laboratory period?

A FAMOUS OLD DISPUTE SETTLED

More than sixty-five years ago Helmholtz and Koenig discussed the question of the objective reality of combinational tones but could not agree. Since then a similar controversy with respect to sidebands has been debated by Fleming, Howe, Colebrook and other eminent radio engineers without arriving at a decision. Now comes the Hoosier high school teacher, Dr. Herbert Hazel, Bloomington, Indiana with the report of a research carried on at Indiana University under Professor R. R. Ramsey that answers the riddle that could not be solved by master physicists. (Hazel, Herbert. "Beat Notes, Combinational Tones, and Sidebands," ***Philosophical Magazine***, Series 7, vol. xix. p. 103. January 1935.) Dr. Hazel summarizes his results as follows:

"There is a difference between beat tones and differential tones. Beat tones, produced by mere addition of frequencies, elicit no response in detecting devices tuned to their frequency.

"Combinational tones or sidebands have objective existence if peak response in a linear periodic circuit is used as the criterion of existence. These derived frequencies are produced by modulation, which is the multiplication of one periodic disturbance by another.

"Modulation can be secured either in linear or non-linear circuits.

"Sound waves do not appreciably modulate one another in air, and their sources do not give appreciable modulation even when coupled together mechanically.

"The Helmholtz-Koenig combinational tone controversy was due to misunderstanding of the conditions for modulation and failure of the experimenters to make their receiving devices independent of the ear.

"The sideband controversy was based on vague definitions of physical existence and upon the illegitimate use of non-linear elements in detecting apparatus."

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Twenty-ninth Meeting

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Cambridge, Mass.

Room 6—120

SATURDAY, MARCH 9, 1935

PROGRAM

9:45 Meeting of the Executive Committee.
10:00 Business Meeting.
10:15 Reports of Committee on New Apparatus and other Committees.
10:45 Address of Welcome: Prof. Francis W. Sears, Department of Physics.
11:00 Address: "The Stratosphere." Prof. Jerome Hunsaker, M.I.T.
11:45 Address: "Infra-red Photography." Prof. Gordon B. Wilkes, M.I.T.
12:45 Lunch in North Hall, Walker Memorial. Price one dollar.
2:00 Illustrated address: "High Speed Motion Pictures." Dr. Harold E. Edgerton, M.I.T.

Prof. Wilkes will take a picture of our members in a pitch black room by Infra-red Photography. It will be developed and shown on the screen during his address.

After Dr. Edgerton's address members may inspect the George Eastman Research Laboratories. Guides will be furnished.

The Industrial Trips Committee announces a field trip to the Edgar Station of the Boston Edison Company at Weymouth, the pioneer in high pressure steam. Permission has also been obtained to go through the transmitting station of WEEI. Meet at the plant at 9:30 A.M., Saturday, March 23, 1935.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, William E. Smith, English High School, Boston, Mass.
Vice-President, Joseph M. Arthur, St. Mark's School, Southboro, Mass
Secretary, William W. Obear, High School, Somerville, Mass.
Treasurer, Preston W. Smith, Rivers School, Brookline, Mass.

BUSINESS MEETING

The following were elected to active membership: Irving T. Coates, Holten High School, Danvers, Mass.; John J. May, Boston Trade School, Roxbury, Mass.; Francis D. Whittemore, Roxbury Memorial High School for Boys, Boston, Mass.

It was voted to extend the thanks of the Association to the officials of Massachusetts Institute of Technology for their kindness in providing such excellent facilities for this meeting.

Prof. Sears of the Physics department welcomed us in behalf of the Institute. He enumerated some of the projects under way in the various

research laboratories and gave us a cordial invitation to visit them after the afternoon lecture.

REPORTS OF COMMITTEES

For the New Apparatus Committee Mr. Ford showed a small hydro-electric plant; Mr. Hollis Hatch showed an improved form of linear expansion apparatus; and Mr. Stanley showed a photoelectric photometer.

MAGAZINE LITERATURE AND NEW BOOKS

Mr. C. W. Staples, Chairman, *Chelsea High School*

NEW BOOKS

Isaac Newton, A Biography, by Louis Trenchard More. New York. Charles Scribner's Sons. 675 pages. $4.50. Clearing up many of the lesser known facts of Newton's life and work.

DuPont Magazine gives an account of a 12 volume set of "The Smithsonian Scientific Series" prepared by the officers and scholars of the Institution under direction of its Secretary, Dr. Charles G. Abbot. Each author writes of that branch of knowledge which has been his life-long study. Additional information may be had from Smithsonian Institution Series, Inc., Empire State Building, N. Y.

Harvard University. Jefferson Physical Laboratory. "Contributions from the Laboratory and from the Cruft High-Tension Electrical Laboratory of Harvard University" for the years 1932–33. Harvard University Press, 1934. $2.50.

Theoretical Physics, by G. Joos. $6.50 Stechert; 25's, Blackie and Son. 1934.

High Voltage Physics, by L. Jacob. Methven, 1934. 3's.

Experimental Physics, by G. F. C. Searle. Macmillan Co. $4.50. 1934. Cambridge University Press. 16's.

Electrons, Protons, Photons, Neutrons, and Cosmic Rays, by R. A. Millikan. University of Chicago Press. 1935. $3.50.

On the Wing, by David Masters. Henry Holt & Co. 1934. Achievements of flyers from Wright brothers to present time.

Railway Engines of the World, by Brian Reed. Oxford University. 1934.

Elements of Water Supply Engineering, by Earle Lytton Waterman. Wiley, 1934.

Physics Workbook, by Charles E. Dull. Henry Holt & Co. 1934. A new work-book following the order of Dull's *Modern Physics,* but may be used with any High School text-book. Semi-loose-leaf form.

MAGAZINE LITERATURE

Astrophysics

"Observing the Corona," by A. M. Skellett, *Bell Laboratories Record.* December, 1934. P. 113.

"Planetary Phenomena in 1935," by Herbert C. Wilson, *Popular Astronomy.* January, 1935. P. 19.

"New Kind of Planet Finder," *Popular Science Monthly.* February, 1935. P. 54.

"L'Etoile Nouvelle de la Constellation d'Hercule," *L'Illustration.* Dec. 29, 1934. P. 598.

"Bei den Sternsehern von Neubabelsberg,—Ein Besuch auf Deutschlands grösster astronomischer Forschungstatte," *Daheim*. Jan. 3, 1935. P. 4.

Atmosphere

"The Society Announces New Stratosphere Flight," by Gilbert Grosvenor, *The National Geographic Magazine*. Feb., 1935. P. 265.

"Air-Conditioning in Rockefeller Center Development," by A. Warren Canney (Illustrated description), *Ice and Refrigeration*. Jan., 1935. P. 15.

"Liquid Air Used as Fuel by Remarkable Japanese Engine," *Popular Science Monthly*. Feb., 1935. P. 46.

Atomic and Molecular Physics

"Disintegration of Nitrogen by Neutrons," by Franz N. D. Kurie, *The Physical Review*. Jan. 15. P. 97. (Other articles of interest in same number.)

Aviation

"Planes that go Straight Up Open New Field for Aviation," by Edwin Teale. *Popular Science Monthly*. March, 1935. P. 13.

"High Altitude Flying," *Science*. 81: sup. P. 6–7. Jan. 25, 1935.

"Mysterious New Aircraft Power by Reaction Motor," *Popular Science Monthly*. March, 1935. P. 13.

"L'Industrie Aeronautique et les Armements Aeriens," by Henri Bouche. Le XIVe Salon de L'Aeronautique. First half of entire number. *L'Illustration*. Nov. 17, 1934.

"Safer Landings with Three-Wheeled Amphibian," by Stewart Rouse, *Popular Science Monthly*. Feb., 1935. P. 27.

"Regular Airship Flights Berlin to New York Will Start Next Summer," *Popular Science Monthly*. Jan., 1935. P. 20.

"Aircraft Can Fly as One or Two Planes," *Popular Science Monthly*. Jan., 1935. P. 41.

Construction

"World's Largest Bridge," (Under Construction, San Francisco to Oakland), *Popular Science Monthly*. Feb. 1935. P. 22.

Diesel Engines

"Diesel Maintenance Cost Analysis," by Paul M. Thayer ($1 per H.P. year), *Power Plant Engineering*. Feb., 1935. P. 97.

"Diesel Powered Trucks are Dominating the Field," *Diesel Power*. Jan., 1935. P. 44.

"Culpeper, Va., Installs Municipal Diesel Light Plant," *Diesel Power*. Jan., 1935. P. 22.

"Maintenance Cost of Diesel Locomotives," *Diesel Power*. Jan., 1935. P. 22. (Total maintenance cost of this type locomotive well below average for boiler alone of its steam competitor. Average maintenance per hour a locomotive was in service was but 52.2 cents.)

Electricity

"Advances in Power Apparatus," *Electric Journal*. Jan., 1935. P. 6.

"Penn Railroad Now Has Greatest Electrified Mileage," *Transit Journal*. Jan. 1935. P. 29.

"IV. A Review of Cathodic Protection of Pipe Lines," (3 other articles in preceding numbers) by A. F. Bridge, *American Gas Journal*. Jan., 1935. P. 31.

"High Frequency Resistance Standard," by W. D. Voelker, *Bell Laboratories Record*. Jan., 1935. P. 136.

"The Six-String Oscillograph," by A. M. Curtis, *Bell Laboratories Record*. Jan., 1935. P. 145.
"Lightning Discharges to Grounded Conductors," by J. C. Jensen, Bibliography, *Science Monthly*. Dec., 1934. P. 560.
"Lightning Strikes Twice and Even Ten Times in One Place," *Scientific American*. Nov., 1934. P. 264.
"New Plan for the Production and Transmission of Electrical Power," by W. Davis, *Science*. 81: sup. P. 8. Jan. 11, 1935.

Friction

"A New Lubrication Oil," (Auto), *Diesel Power*. Jan., 1935. P. 46.
"Hard New Abrasive Rivals Diamond," *Popular Science Monthly*. March, 1935. P. 42.

Heat

"1934 Progress in Steam Turbines," *Electrical Journal*. Jan., 1935. P. 10.

Historical and Economic

"Philatelic Engineering. Technological Achievement as Recorded on Postage Stamps," *Technology Review*. Jan., 1935. P. 136.
"The Trend of Affairs," *Technology Review*. Jan., 1935. P. 125.
"Progress and Confusion in Science," by D. Ramsey, *American Mercury*. Dec., 1934. P. 430–5.
"Newton and the Modern Age," by F. S. C. Northrup, *Sat.-R. Lit.* Feb. 2, 1935. P. 453–4.
"Franklin's Glass Organ Still Used," *Popular Science Monthly*. Feb., 1935. P. 29.
"If Industry Gave Science a Chance," by J. D. Bernal, *Harper's Magazine*. Feb., 1935. P. 257.
"Harnessing Scientific Discoveries," by P. G. Agnew, *Scientific Monthly*. Feb., 1935. P. 170.

Light

"La Lumiere Jaune pour les Automobiles," *L'Illustration*. Dec. 22, 1934. P. 583.
"The New Lighting," *Electric Journal*. Jan., 1935. P. 23.
"Translucent Laminated Plastics Open New Vistas to Architects and Industrial Designers," *Modern Plastics*. Jan., 1935. P. 29.
"New Science of Seeing," by E. King, *Pictorial Review*. Nov., 1934. P. 60.
"Measurement of the Velocity of Light in a Partial Vacuum," by A. A. Mickelson and others, *Science*. 81: Jan. 25, 1935. P. 100.
"Gun Shoots Light Ray Instead of Bullets," *Popular Science Monthly*. Jan., 1935. P. 17.

Materials

"What Plastic Molding Involves," *Modern Plastics*. Jan., 1935. P. 9.
"Blown Glass. Its Manufacture and Decoration," by C. L. Roos, *The Jeweler's Circular*. Jan., 1935. P. 85.
"From Tungsten Powder to Finished Carbide Tools," (Pictorial Description of Carboloy Process of Making Cemented Carbide Tools), *Iron Age*. Jan., 1935. P. 30.
"National Mineral Policy Proposed," *Engineering and Mining Journal*. Jan., 1935. P. 4.

Optics

"How Spider Web Is Put in Telescopes," *Popular Science Monthly*. Feb., 1935. P. 47.

Photography

"Advanced Amateur Photography; Infra-red and Ultra-violet," by A. G. Ingalls, *Scientific American*. Dec., 1934. P. 229.

"Miniature Enlarger," by R. O. Bieling, (Diagrams), *American Photography*. Dec., 1934. P. 754.

"Modern Wonder Camera Sees Like Cats in the Dark," by Walter E. Burton, *Popular Science Monthly*. March, 1935. P. 40.

"The New Telephotograph System," by F. W. Reynolds, *Bell Laboratories Record*. Feb., 1935. P. 17.

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"Power to Come by Radio," by E. C. Hansen, (Diagrams), *Popular Mechanics*. Nov., 1934. P. 696.

"Hunting Echoes, New Radio Sport," by G. H. Waltz, Jr., *Popular Science Monthly*. Dec., 1934. P. 125.

"Radio Echoes," *Science*. 80: 394–5. Nov. 2, 1934.

"How to Build an Inexpensive Set Tester," (Diagrams), *Popular Mechanics*. Dec., 1934. P. 904.

"Radio Receiving Apparatus, Portable. Beginners Can Build this Portable Short-Wave Receiver," by F. Lester, (Diagrams), *Popular Mechanics*. Dec., 1934. P. 902.

"Low-Cost Rectifiers for Extra Speakers," by P. H. Nelson, (Diagrams), *Popular Science Monthly*. Dec., 1934. P. 62.

"Amateur Phone Transmitter," by J. A. Worcester, Jr., (Diagrams), *Popular Science Monthly*. Jan., 1935. P. 56.

"Radio and the Future," by G. Marconi, *Commonweal*. Jan. 18, 1935. P. 337.

"Electric Robot Trains Singers," *Popular Science Monthly*. Feb., 1935. P. 19.

"Disturbances in Radio Transmission," by A. M. Skellett, *Bell Laboratories Record*. Feb., 1935. P. 164.

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"Sun Motors," *Power Plant Engineering*. Feb., 1935. P. 88.

"Electric Motor Powered by Sunlight," *Popular Science Monthly*. Jan., 1935. P. 31.

Sound

"Loudness and Pitch," by Harvey Fletcher, *Bell Laboratories Record*. Jan., 1935. P. 130.

"The Long Struggle Against Cable Cross-Talk," *Bell Telephone Quarterly*. Jan., 1935. P. 3.

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"Latest in Locomotives," *Popular Mechanics*. Feb., 1935. P. 219.

"Speed an Outstanding Development in 1934," by Doster and Laying, *Railway Age*. Jan. 26, 1935. P. 108.

"Les Essais en France d'une Locomotive Anglaise a Grande Puissance," *L'Illustration*. Dec. 15, 1934. P. 536.

Welding

"Stress-Relieving Is Perfected for Large Welded Vessels," by F. W. Thompson, *Gas Age Record*. Jan. 26, 1935. P. 67.

"Spot-Welding," by Lawrence Ferguson, *Bell Laboratories Record*. Dec., 1934. P. 109.

Mr. Miller called attention to an excellent scientific article in the March *Atlantic*, "Breath of Life."

Mr. W. E. Smith recommended the book *Limitations of Science*, by J. M. Sullivan.

CURRENT EVENTS

J. P. Brennan, Chairman, *Somerville High School*

Studies at the Huancago, Peru, station of the Carnegie Institution are leading to the belief that the daily early morning swing of the compass needle toward the east is due to the varying ionization of the upper air, the ionosphere. It is thought that the increased ionization of this layer may be due to ultra-violet rays of the rising sun.

Experts of the Department of Agriculture are working on a scheme to keep fruit in transit from freezing by freezing wet sawdust. A layer of wet sawdust is put on the floor of the car in which fruit is to be shipped. When the fruit train passes through a district where the temperature is just below 32° Fahrenheit, the wet sawdust freezes and the latent heat of the water is released to keep the fruit from freezing. There is enough heat to keep the fruit from freezing, but not enough to cause the upper air of the car to become overheated as sometimes occurs with other types of car heaters. This overheating of the upper part of the car is thought to be responsible for the mealy character and tastelessness of apples shipped from the Northwest.

The scheme of animated cartoons which has made possible the "Silly Symphonies" of Walt Disney is being used to show what happens in electrical circuits. Photographs of waves shown by the oscillograph are made into a film and thrown on the screen. The resulting "moving picture of electric waves" has been found to be of great assistance in enabling students to visualize what goes on when a switch is closed.

Dr. Gilbert N. Lewis of the University of California is working on a new theory to explain the derivation of the various elements in the universe. Dr. Lewis is basing his work on a study of the relative amount of the various elements in the stony meteors and the earth's crust and the composition of the iron-nickel type of meteor. According to new theory, cosmic rays could have split atoms of iron and nickel to form atoms of silicon. Silicon in turn could have split to form atoms of helium and magnesium. By such splitting, eight of the eleven most abundant elements of the stony meteorites may be accounted for.

An attempt to account for unexplained differences in astronomically controlled clocks in Europe and North America has led to the discovery that tidal waves in the earth's crust cause an east and west movement of approximately sixty-three feet. Clocks on the time signals broadcast from Annapolis, Rugby and Bordeaux seem to indicate that these differences increase and decrease according to the hour angle of the Moon.

NOTES ON THE STRATOSPHERE

By Prof. J. C. Hunsaker, *Massachusetts Institute of Technology*

The Stratosphere is a conception of our own century, due to the astonishing discovery in 1902 both by Tisserenc de Bort and by Assmann that above 11 km. the air no longer grows colder but seems to mark the beginning of an isothermal layer. Tisserenc de Bort named the lower atmosphere the Troposphere and the upper atmosphere, where temperature inversion begins, the Stratosphere.

This discovery has led to continuous study by all the means at man's disposal to determine the nature and composition of this Stratosphere. Nevertheless its study remained of academic interest, principally to geophysicists and astronomers, until the further discovery that a conductive layer in the Stratosphere (Kennelly-Heaviside layer) played a major part in transmission of radio signals round the curvature of the earth. Investigation of its nature has more recently been stimulated by discussion of cosmic rays, changes in solar radiation, and by the actual penetration by man into the lower Stratosphere. In addition, recent research in dynamic meteorology indicates that the varying level of the lower Stratosphere or tropopause may play a part in our apparently unpredictable weather sequence.

Finally, we are interested practically in the Stratosphere because recent improvements in aeronautical engineering hold out hope that the Stratosphere may yet become an ideal medium for air travel. In the thin air of the Stratosphere there is no weather. Here we have no gusts or convection and no water vapor to condense into snow, ice and cloud. In this stable air, airplanes could fly safely and surely. The basic mechanical inventions needed have already been made and now await only engineering development. These are, first, the supercharger to supply compressed air to the airplane engine so that it may develop its normal power, and to supply similar compressed air to the passengers, and, second, the automatically varying pitch geared propeller, such that in thin air the propeller may still develop the effective thrust needed.

The engineers of the Douglas Company estimate that, at 40,000 ft., cruising speeds of the order of 275 miles per hour are possible with existing equipment. This represents a gain of 69% in speed at a cost of 6% increase in power. The price per passenger mile should be of the order of 4 or 5 cents, or about the same as for air transport at lower speeds at lower levels. A flight across the continent would cost $125 and take 10 hours time. A Stratosphere flight requires a supercharged cabin and equipment of higher initial cost. Otherwise high flying might be cheaper. Such high flights would not be economical for short distances on account of the climb and descent involved. If stops were made every 700 miles the cost is as stated above. If refueling stops were made every 1500 miles, the cost per mile is about doubled.

Hence we may predict that long distance Stratosphere flights, non-stop to Europe will not be cheap, but they will be fast. They may constitute a super first class service by daylight to Europe at a higher rate than any other other means of transport.

There is a widespread notion that, in the Stratosphere, there is a constant west wind of hurricane force. This is fantastic. Observations of the drift of sounding balloons, volcanic dust, meteor tracks, etc., indicate that winds may blow from any direction with west and north winds more frequent. The wind velocity generally increases with altitude up to the tropopause and then diminishes. The dust of Krakatoa was seen to move

at a maximum of 50 miles per hour. Other maximum velocities from 20 to 60 miles have been observed. These velocities are not serious for a 300 mile-an-hour airplane.

Composition

The composition of the Stratosphere is known directly only up to some 20 Km., where the proportions of N and O are normal with no unusual fraction of H, He, and the rare gases. Water vapor and CO_2 are nearly absent. It is estimated that up to 100 Km. the atmosphere is of normal proportions of N and O but at extreme heights an envelope of H and He has been predicted. But above 200 Km. the mean free path of a molecule should be 1 Km. A small change in solar energy could produce a relatively enormous disturbance in such attenuated gas and pulsations are suspected which cause a loss of fast particles to space. This loss of matter can be balanced by gains from cosmic material picked up and by the discharge of gases from the earth.

Gutenberg estimates that H will be continuously lost to space and that an upper envelope of H is unlikely due to its high molecular velocity at the warm temperature of the Stratosphere. If the temperature were somewhat higher He would be lost. Consequently N appears to be the most likely constituent of the upper reaches. The presence of N is indicated by the green line in the light from the night sky, from meteors and from the aurora. Calculations of diffusion equilibrium also indicate N.

If the Stratosphere were H it would have to be very much colder, but for N, 200°K at 40 Km. to 1000° K at 140 Km. The lower Stratosphere is actually of the order of 200°K or higher.

Origin

The suggestion has been made that the atmosphere is made up of cosmic material captured from space, but the probable rate of such capture is only 10% of the necessary rate to create our atmosphere within the probable life of our planet, 3×10^9 years. On the other hand, the rate of supply of N, H, He, CO_2 from the earth is ample to create the atmosphere in a fairly short time. Helium is estimated to be given off at 3×10^8 m^3/yr. and Hydrogen from volcanic sources at 8×10^{11} $Km.^3$/yr. The supply of H and He is so great that continuous loss of these gases is to be expected.

Adiabatic Troposphere

In the Troposphere the air is mixed by convection. Air rises and is cooled until an equilibrium density is reached. In general we find the temperature lapse rate less than 1° per 100 m elevation. When the lapse rate is less than this, the air is stable, where more, it is unstable, and violent convection will take place with consequent change of state of the water content. In general, the average lapse rate is somewhat less than the adiabatic all over the world. In our latitude, this rate obtains up to some 10 Km. while in the tropics it extends to 18 Km.

Hence the bottom of the Stratosphere is higher and colder in the tropics, say at 18 Km. and $-75°C$, while in our latitude it is at about 10 Km. and $-50°C$.

Isothermal Stratosphere (Stable Equilibrium)

The lower Stratosphere has been found to be substantially isothermal. This is a very stable condition and gives rise to no convection. There is a good deal of indirect evidence that the isothermal state extends upwards indefinitely.

(a) Meteorites observed with a speed of 12 to 19 Km./sec. would not be visible unless the temperature of the Stratosphere at 50 to 100 Km. were of the order of 220–330°K (Lindemann-Dobson).

(b) Abnormal propagation of sound requires a similar warm Stratosphere (Gutenberg).

(c) Calculations of ozone at 40 to 60 Km. require $T = 300°$ or more.

(d) Radiation equilibrium indicates a temperature of more than 200°K.

W. J. Humphreys gives the following rough approximation:

T_1 of molecule

T_2 of earth (252°K, effective black body temp.) absorbed by molecule
from earth σT_2^4
absorbed by molecule from sun 0
radiated by molecule (both sides) $2\sigma T_1^4$

$\therefore T_1^4 = \frac{1}{2} T_2^4$ or $T_1 = 212°K$, a minimum.

Actually T_1 must be higher than this figure because of absorption by ozone, dust, moisture, etc.

Extent of the Stratosphere

Meteors begin to show at 100 Km. and go out at 25 to 50 Km., showing strong N lines in their spectrum.

Spectroscopic measurements of the zenith sky at sunset indicate absorption of ultra-violet by ozone, distributed below 40 Km. with a layer of average height about 22 Km.

Afterglow is due to a probable lack of uniformity in the air. The first band with the sun 8° below the horizon is 15 Km. high (tropopause). The second band with the sun down 18° is about 80 Km. high, the same altitude as is observed for.

Noctilucent Clouds which shine late at night from reflected sunlight and are seen around the summer solstice. After the Siberian Meteor of 1902 they were seen for two days. After the Krakatoa eruption in 1885, such clouds were seen at intervals for 4 years. The height is of the order of 70–80 Km.

Nacreous Clouds (Mother of Pearl) are believed by Humphreys to be due to upheavals in the Stratosphere condensing a slight trace of water vapor into spherical particles. Their height is of the order of 25 Km.

Kennelly-Heaviside Layer. The existence of a radio roof at 80–90 Km. is inferred from radio transmission experiments giving reflection time and

interference. On winter nights the roof may lift quickly to 250–350 Km. It is believed that the upper gases are ionized by solar radiation, probably by x-rays that are absorbed and do not reach the earth, rather than ultraviolet or corpuscular radiation.

Aurora-Borealis. The conducting layer seems to be associated with the Northern Lights which have been intensively studied. Shortly after sunset the light comes down to 400 Km. and later in the night to 100 Km. Solar radiation is supposed to excite radiation from some gas molecules and to ionize others.

Zodiac Light. This pyramid of light, especially in the tropics, appears after sunset in the west with a "gegenshein" opposite. The height of the top of the light may be 1000 Km. (Schmidt). The explanation is that reflected sunlight comes from an illuminated section of the Stratosphere and it is inferred that the Stratosphere is lens-shaped with the plane of the ecliptic as plane of symmetry.

The lecture was closed with a model demonstration of the effect of radiation on the globe of a Stratosphere balloon like Piccard's in which one side was black and the other white. Professor Piccard arranged to turn the black side of his globe toward the sun if the temperature inside fell uncomfortably and to turn the white side toward the sun if too hot. The model exposed to the radiation from a carbon arc illustrated how the temperature of the air inside can be controlled.

A comprehensive survey of physical knowledge of the Stratosphere may be found in Vol. 9, Handbuch der Geophysik (Aufbau der Stratosphäre), by B. Gutenberg.

A survey of the possibilities of air transport is to be found in the *Journal of the Aeronautical Sciences*, January, 1935. (High Altitude Flying by W. B. Oswald.)

INFRA-RED PHOTOGRAPHY

By Prof. Gordon B. Wilkes
Massachusetts Institute of Technology

For many years in connection with heat transfer work, I have been interested in the infra-red portion of the spectrum because, with the exception of solar radiation, nearly all of the heat transferred by radiation such as that from furnaces, etc., lies in this long wave length invisible region. During a recent popular science lecture on heat radiation, I attempted to show the similarity of light and infra-red radiation by taking a photograph in absolute darkness, exposing the subject to infra-red radiation and using an infra-red sensitive plate in the camera.

I will attempt to duplicate this experiment now using a 500-watt lamp in a projection lantern and a No. 87 infra-red filter in place of the usual slide. The lantern is well shielded so that there is no visible light and of course the room is darkened so that we have absolute darkness. An East-

man Type 1R infra-red sensitive plate was used with an aperture of $f/4.5$ and a 6-second exposure.

Wien's Displacement Law states that the wave length of maximum energy in the radiation of a "black body" multiplied by the absolute temperature of the radiator is equal to a constant or

$$\lambda_1 T_1 = \lambda_2 T_2 = 2885 \times 10^{-3} \text{ mm. } ^\circ\text{K.}$$

In other words, as the temperature of a radiator becomes less, the wave length, corresponding to the maximum energy becomes greater. The following table will give one an idea of the magnitude of this shift in wave length with various sources of radiation:

Source of radiation	*Temperature*	*Wavelength of maximum energy*
Sun	6000°K.	0.48μ
Tungsten filament	2600	1.11μ
Sun-bowl heater	1000	2.88μ
Flat iron	700	4.13μ
Room temperature	300	9.6μ

Only the sun has its wave length of maximum energy lying in the visible portion of the spectrum which extends from about 0.4μ to 0.7μ.

Previous to 1875, photographic plates were only sensitive to wave lengths between 0.31 and 0.50 which produce primarily the blue, violet and a little of the ultra-violet in our spectrum. Since that time the range of sensitivity has been gradually increased to both shorter and longer wave lengths so that the range at present lies between 0.1μ and 1.0μ.

This increase in sensitivity at various wave lengths is produced by the addition of dyes to the emulsion. Orthochromatic plates were first produced by the addition of dyes which made them sensitive to green light, panchromatic plates were produced in much the same manner making them sensitive to practically the entire visible spectrum and now we have infra-red plates which have a maximum sensitivity in the infra-red corresponding to a wave length of about 0.82μ.

The various slides shown will indicate the much greater detail that is possible when a picture is taken with infra-red plates rather than ordinary plates. Infra-red radiation penetrates haze, water vapor, etc., much better than the shorter wave length radiation of blue, violet and ultra-violet, as shown by the following table taken from an article by George E. Brown in the British Journal *Photographic Alumanac for 1933*.

Transmission through 5 miles of Atmosphere

Violet	50–70%
Orange-red	80–90%
Infra-red	90% plus.

If one uses an infra-red filter over the lens of the camera with infra-red plates, unusual effects are produced. Green vegetation appears very light

giving the effect of snow covered fields while the sky appears nearly black because the blue is eliminated by the red filter.

The advantage of infra-red sensitive plates for long distance photography are obvious and some remarkable photographs have been made of mountains many miles distant. Probably the most interesting long distance photograph was made by Capt. Stevens in 1931, when he photographed the Andes Mountains in South America from a distance of 287 miles although the mountains were quite invisible to the human eye. This is said to be the first photograph ever taken that showed the curvature of the earth laterally. It was taken from an aeroplane at an altitude of 21,000 feet while the highest mountain in the range was in the neighborhood of 23,000 feet above sea level. Capt. Stevens used a lens with 20-inch focus, infra-red filter and 1/20 of a second exposure. A year later, he took a photograph of Mount Shasta when the camera was 331 miles from the mountain.

The first group photograph ever made in total darkness was taken by the Eastman Kodak Company in 1931. In this case, fifteen 1-kilowatt lamps in reflectors were pointed toward the ceiling through the top of a booth. Over the top of the booth, sheets of Wratten No. 87 infra-red filter were placed so that no visible light could be seen by the audience. The exposure was 1 second at $f/3.5$ on an Eastman Infra-red sensitive plate, Type 1R.

It is also possible to photograph with the radiation from electric flatirons. Two of these at a temperature of about 400°C will give sufficient radiation to obtain a photograph of a plaster bust with infra-red plates. No filter is required in this case as there is no visible radiation at 400°C. Eastman Kodak Company has made such a photograph with an exposure of one hour at $f/4.5$.

The use of infra-red photography during wartime is obvious enabling photographs of enemy territory to be taken at high altitudes beyond the reach of gunfire. The U. S. Army has dropped a finished photograph from a plane only 7 to 10 minutes after the exposure. The U. S. Geological Survey as well as the Coast and Geodetic Survey make important use of this type of photography in connection with their map work.

It has been stated that it is possible to decipher some altered documents by this means and the biologist as well as the medical profession believe that it may be of service in detecting conditions slightly below the surface of leaves or the skin due to the penetrating power of infra-red radiation.

The astronomer and spectroscopist find that it is a very important aid in their work.

For those interested in photography as a hobby, a new field is open that has many very interesting phases.[1]

In conclusion I wish to express my thanks to Dr. Walter Clark of the Eastman Kodak Company for his many helpful suggestions in regard to infra-red photography in absolute darkness.

[1] See an article by Dr. Walter Clark in *American Photography* Vol. 28, 1934. P. 140.

HIGH-SPEED MOTION PICTURES

By Dr. Harold E. Edgerton
Massachusetts Institute of Technology

The stroboscope and the high-speed motion-picture camera are research instruments which enable one to "see" actions that are too fast for the unaided eye to examine. The actions are apparently slowed down, permitting the observer to study them in detail. In engineering and scientific work it is not sufficient just to see the actions. Measurements are needed to put the motions upon a rational basis, and the high-speed camera is particularly adapted to this, since it records the position and distortion of objects directly as a function of time.

The name "stroboscope" was handed down to us by early experimenters about one hundred years ago. It means, when literally translated from its Greek roots, "whirling watcher." A stroboscope is an instrument which makes it possible by intermittent illumination to watch rotating or vibrating objects. The flashes of light are controlled so that they occur at intervals of time corresponding to the interval of time for one revolution or one vibration. In this manner the eye sees the object that is under observation at the same place in each revolution, and the eye holds over the successive images by means of the persistence of vision. Should the frequency of the flashes of light be slightly faster or slower, then the object will appear to rotate backward or forward at a slow rate, corresponding to the difference frequency. Thus by means of the stroboscope a rapidly-moving machine may be made to go at an apparently slow rate of speed, and the eye is able to follow the motion.

The stroboscope finds extensive use in experimental laboratories where machinery is being developed. As an example, automobile manufacturers find constant use in the development of new models. The surges of the valve springs, the operation of the camshaft, the manner in which oil is splashed by the crank shaft, the vibration of the fan blades, the shimmy of the front wheels, the vibration of the fenders and body, the distortion of the crank shaft, and so forth, are some of the problems which the stroboscope gives a visual and accurate analysis of.

The speed of a rotating object is easily determined by the stroboscope, since the frequency of the flashes and the speed of rotation correspond when the object appears stationary. The advantage of the stroboscope for this purpose is the fact that no mechanical connection to the rotating object is needed. This becomes of paramount importance for cases involving inaccessible shafts and light, delicate, or small parts which would be greatly retarded if they were required to drive a speed counter of conventional design.

The usefulness of the stroboscope is limited to problems involving periodic motions fast enough so that the persistence of vision holds over the successive images. Many problems do not meet these requirements, and it is here that the high-speed motion pictures taken at a high rate of speed

and then projected normally show the motion reduced. The greater the speed of the camera, the slower the speed of the action on the screen.

Mechanical difficulties prevent motion-picture cameras of the usual intermittent-motion type from being driven at more than about ten times normal speed. With a brilliant stroboscopic light, however, it is possible to make a motion-picture camera that takes pictures at much faster rates upon film that does not stop while each picture is being taken. The flashes of light must be short enough so that a negligible blur results on the film, and furthermore the flashing time must be accurately determined so that the pictures are properly framed on the film for subsequent projection.

During the address the stroboscope was demonstrated and the details of the high-speed stroboscopic-light motion-picture camera were explained. In conclusion some high-speed motion pictures of a variety of subjects were projected.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1372, 1376, 1381—*Charles W. Trigg, Los Angeles.*

1378—*Glynden Easley, Portales, N. Mexico.*

1376—*Harno Miyamoto, Honolulu.*

1382. *Proposed by Charles W. Trigg, Comnock College, Los Angeles.*

Resolve $x^8+398x^4y^4+y^8$ into two polynomial factors with integral exponents.

Solution by Maxwell Reade and Rose Kowaloff, Brooklyn, N. Y.

(1) $x^8+398x^4y^4+y^8=x^4y^4\left(\frac{x^4}{y^4}+398+\frac{y^4}{x^4}\right)=x^4y^4\left(Z^4+398+\frac{1}{Z^4}\right)$ where $Z=\frac{x}{y}$.

Now, let $Z-\frac{1}{Z}=K$, then $Z^2+\frac{1}{Z^2}=K^2+2$ and $Z^4+\frac{1}{Z^4}=K^4+4K^2+2$.

By substitution,

(2) $x^4y^4\left[Z^4+398+\frac{1}{Z^4}\right]=x^4y^4(K^4+4K^2+400)=x^4y^4(K^2-6K+20)(K^2+6K+20$

which reduces, when K is replaced by $\frac{x^2-y^2}{xy}$, to a pair of factors

$$[(x^2-y^2)^2-6xy(x^2-y^2)+20x^2y^2)][(x^2-y^2)^2+6xy(x^2-y^2)+20x^2y^2)]$$
$$=(x^4+6x^3y+18x^2y^2-6xy^3+y^4)(x^4-6x^3y+18x^2y^2+6xy^3+y^4),$$

which are factors of the given trinomial.

Other solutions involving imaginary and irrational coefficients were given. The use of the theorem of undetermined coefficients yielded the results given above.

Solutions were also offered by A. Struyk, Paterson, N. J.; H. Leo Juditz, N. Y. C.; Harno Miyamoto, Honolulu; Margaret Joseph, Milwaukee, Wis.; Charles Koren, Bayonne, N. J.; David Blackwell, Centralia, Ill.; W. E. Buker, Leetsdale, Pa; and the proposer.

1383. *Proposed by D. C. Duncan, University of California.*

The points of intersection of the two external tangents, the two internal tangents and the centers of the two circles are four harmonic points.

Solution by A. Struyk, Paterson, N. J.

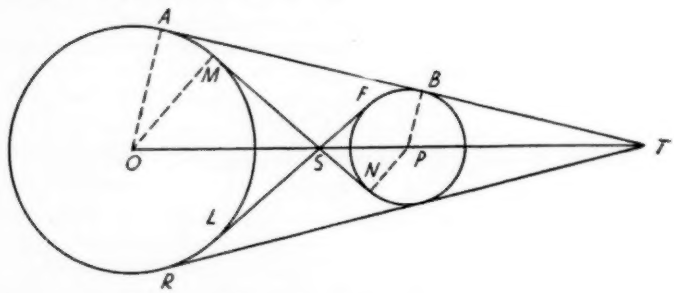
Let the two circles be O and P, with external tangents meeting at T, and internal tangents intersecting at S.

Draw radii to points of tangency.

Points O and P are each equidistant from AT and TR, and therefore lie on the bisector of angle ATR. Hence O, P, T are collinear.

Point O is equidistant from MN and LF. Hence OS is the bisector of angle MSL, and OS produced bisects angle FSN. Point P is equidistant from MN and LF, and hence lies on the bisector of angle FSN. Hence S, P, T are collinear.

Therefore O, S, P, T are collinear.



Triangles OMS and PSN are similar and $OM:NP=OS:SP$. (1)

Triangles OAT and PBT are similar and $OA:PB=OT:PT$. (2)
Now $OA=OM$ and $PB=NP$. Hence $OA:PB=OM:NP$. (3)
From (1) and (2) using (3), $OT:PT=OS:SP$ which shows that O, S, P, T are four harmonic points.

Other solutions offered by Chas. C. D'Amico, Albion, N. Y.; Charles W. Trigg, Los Angeles; Howard R. Harold, Tonkawa, Okla.; M. J. Turner, Muncie, Ind.; Richard A. Miller, University of Miss.; Maxwell Reade, Viola Kantrowitz and Lois Stein, Brooklyn College, and the proposer.

1384. *Proposed by W. E. Buker, Leetsdale, Pa.*

A sphere is tangent to each of two skew lines. Find the locus of its center.

Solution by Charles W. Trigg, Cumnock College, Los Angeles

Let the common perpendicular of the two lines be the OZ-axis, and the plane perpendicular to this at its midpoint be the XY-plane, in which the OX-axis is the projection on the plane of that skew line which is below the plane. Then let the distance from the origin to each of the skew lines be a, so that their equations are $z=-a$, $y=0$ and $z=a$, $y=mx$, where m is the tangent of the angle between the projections of the lines on the XY-plane.

The distance from any point $P(x,y,z)$ to the first line is $\sqrt{y^2+(z+a^2}$. The distance from P to the second line is

$$\sqrt{(z-a)^2+\frac{(mx-y)^2}{m^2+1}}.$$

If a sphere of variable radius is tangent to each of the lines, the radii drawn to the points of tangency are perpendicular to the lines. Hence if P is the center of the variable sphere, the distances are equal and

$$y^2+(z+a)^2=(z-a)^2+\frac{(mx-y)^2}{m^2+1}.$$

Clearing this of fractions and simplifying,

$$m^2x^2-2mxy-m^2y^2=4az(1+m^2).$$

This hyperbolic paraboloid, which is a saddle-like surface, is the locus of the center of the variable tangent sphere. It may be noted that when $m=0$, the surface becomes $z=0$. Thus as the skew lines approach parallelism, the surface approaches a plane.

As a sphere with radius, r, moves so as to be always tangent to the line, $z=-a$, $y=0$, its center generates the cylindrical surface, $y^2+(z+a)^2=r^2$. The same sphere, maintaining tangency to the line $z=a$, $y=mx$, generates the cylindrical surface, $(z-a)^2+\dfrac{(mx-y)^2}{m^2+1}=r^2$. If the sphere is tangent to both skew lines then the locus of its center is the space curve which is the intersection of these two cylindrical surfaces, and is defined by their equations taken jointly. This curve lies on the aforesaid hyperbolic paraboloid It is evident that for the curve to be real, $r\geqq a$. If $r=a$, the curve contracts to the point $(0, 0, 0)$. If $r>a$, as $m\to 0$, the locus approaches two parallel lines in the XY-plane.

Solutions were also offered by A. Struyk, Paterson, N. J.; Norman Anning, University of Michigan, and Dewey C. Duncan, University of California.

1385. *Proposed by Maxwell Reade, Brooklyn, N. Y.*

Given a trapezoid $ACDF$ with AF and DC parallel. Also EB is drawn parallel to DC with $\frac{AB}{BC}=\frac{a}{b}$. Let $FA=m$, $DC=n$. Prove $BE=\frac{an+bm}{a+b}$.

Solution by H. Leo Juditz, student, College of the City of New York

1. Thru A and B, draw lines parallel to FD.
   Let their intersection with DC be G and H respectively.
   Let AG intersect EB at K.
2. Since

$$\Delta AKB \backsim \Delta BHC$$

$$\frac{AB}{BC}=\frac{KB}{HC}=\frac{a}{b}.$$

3. But

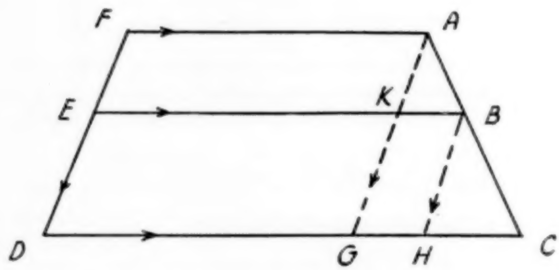
$$KB = EB - m$$

$$HC = n - EB$$

$$b(EB - m) = a(n - EB)$$

$$b(EB) - bm = an - a(EB)$$

$$(a+b)EB = an + bm \text{ and } EB = \frac{an+bm}{a+b}.$$



Solutions also offered by Charles Koren, Bayonne, N. J.; C. H. Secoy, Onalaska, Wash.; Glynden Easley, Portales, N. Mex.; Chas. C. D'Amico, Albion, N. Y.; Martin Bowman, Philadelphia; A. Struyk, Paterson, N. J.; Charles W. Trigg, Los Angeles; Dewey C. Duncan, University of California, Kenneth Carlson, Kearney, Nebr.; J. B. King, Corsica, Pa.; Joseph H. Schottand, N. Y. C.; Joseph L. Stearn, Washington, D. C.; W. E. Buker, Leetsdale, Pa.; M. J. Turner, Ball Teachers College.

1386. *Proposed by Walter H. Carnahan, Indianapolis, Ind.*

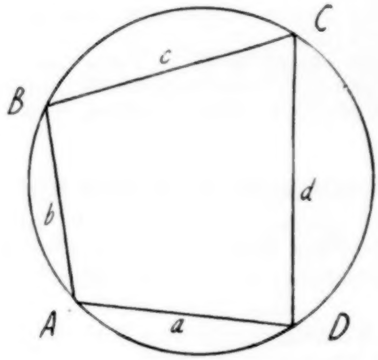
Show that the area of a quadrilateral inscribed in a circle equals $\sqrt{(s-a)(s-b)(s-c)(s-d)}$ where a, b, c, and d are the sides of the quadrilateral and $2s=a+b+c+d$.

Solution by Chas. C. D Amico, Albion, N. Y.

In the inscribed quadrilateral $ABCS$ let $AB=b$, $BC=c$, $CD=d$ and $DA=a$. With A and C are a pair of opposite angles.

This is a special case of problem (1347) proposed by the editor and which

solution by Chas. W. Trigg appeared in the Dec. 1934 issue of this magazine. If the sides of any quadrilateral are a, b, c, d and if a pair of opposite angles are A and C then, it is known that $(\text{Area})^2 = (s-a)\ (s-b)\ (s-c)\ (s-d) - abcd \cos^2 \dfrac{A+C}{2}$.



If the quadrilateral is inscribed in a circle, angles A and C are always supplementary.

$$A + C = 180° \text{ and } \frac{A+c}{2} = 90°$$

$$\cos^2 \frac{A+C}{2} = \cos^2 90° = 0 \ .$$

In any case, if $ABCD$ is an inscribed quadrilateral then $abcd \cos^2 \dfrac{A+C}{2} = 0$.

Therefore, $(\text{Area})^2 = \sqrt{(s-a)\ (s-b)\ (s-c)\ (s-d)}$ for an inscribed quadrilateral.

EDITOR'S NOTE: Solutions to this problem appear frequently in Trigonometries. Other references are as follows: J. Hadamard's "Geometrie," "Brahmagupta's famous generalization of Heron's formula for the cytic quadrilaterals," Johnson's ***Modern Geametry***, p. 80.

Solutions were also offered by C. H. Secoy, Onalaska, Washington; H. Leo Juditz, N. Y. C.; J. B. King, Corsica, Pa.; Charles W. Trigg, Los Angeles; Margaret Joseph, Milwaukee; Charles Koren, Bayonne, N. J.; Joseph L. Stearn, Washington, D. C.; W. E. Buker, Leetsdale, Pa.; Dewey C. Duncan, U. of California; M. T. Turner, Ball Teachers' College; Maxwell Reade, Viola Kantrowitz, and Rose Kowaloff, Brooklyn.

1387. *Proposed by H. C. Torreyson, Chicago, Ill.*

What is the greatest number of spherical balls each exactly one inch in diameter than can be placed inside a rectangular parallelepiped having its inside dimensions exactly $7'' \times 9'' \times 9''$?

Solution by W. R. Smith, Lewis Institute, Chicago

Place a layer of 63 balls using the base which is 7×9. Next place a layer of 48 balls, each ball arranged so that it is over the space between

4 balls in the first layer. Fill the box with alternate layers of 63 and 48 balls. For a height of nine inches, twelve layers may be placed in the box. The height of N layers can be found from the formula $H=1+\frac{\sqrt{2}}{2}(N-1)$ where H is the height of the N layers. N is found to be slightly more than 12. This yields a total of $6\times 36+6\times 48=666$, the arrangement which gives the largest number of balls.

Solutions were also offered by H. C. Torreyson, Chicago; Dewey C. Duncan, Univ. of California; Boris Garfinkel, Buffalo, N. Y.; W. E. Buker, Leetsdale, Pa.; and Maxwell Reade, Brooklyn, N. Y.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: No contributions from High School students appear in this issue. However, students from the following named colleges or universities made considerable contribution:
Ball Teachers' College, Muncie, Ind.
Univ. of Mississippi
Brooklyn College
Eastern New Mexico, Jr. College, at Portales

PROBLEMS FOR SOLUTION

1400. *Proposed by Charles W. Trigg, Los Angeles.*

On each side of a square, equilateral triangles are constructed so as to fall within the square. A portion of the area will be included in all of the triangles, part of it will be in three only, part in two only, and some in only one of the triangles. Determine the portion of the area of the square which falls in each category.

1401. *Proposed by Chas. C. D'Amico, Albion, N. Y.*

A water glass containing water is tilted so that water extends from the top of the glass to a diameter of the base. Find the volume of the water if the glass has an altitude of h and a diameter of $2r$.

1402. *Proposed by Rose Kowaloff and Maxwell Reade, Brooklyn, N. Y.*

In ΔABC, AF is an altitude. Thru a point O, on AF, BD and CE are drawn, D and E being on CA and BA respectively. DE meets BC at L. BD meets EF at K. EC meets FD at G. Prove, L, K, G are collinear.

1403. *Proposed by Dewey C. Duncan, University of California.*

If D is the orthocenter of the ΔABC, then any three of the four points A, B, C, D may be taken as the vertices of a Δ and the fourth point will be its orthocenter.

1404. *Proposed by H. C. Torreyson, Chicago, Illinois.*

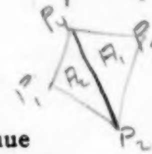
Find x, y and k, such that x and y will be positive integers and k a minimum in the equations:

$$1057x - 411y = 212$$
$$x + y = k.$$

1405. *Proposed by Lester Dawson, Wichita, Kansas.*

If P_1, P_2, P_3 and P_4 be the vertices of a plane quadrilateral, in counter-clockwise order prove that the

$$\text{Area} = \frac{1}{2}\begin{vmatrix} X_1 & Y_1 & 1 & 1 \\ X_2 & Y_2 & 0 & 1 \\ X_3 & Y_3 & 1 & 1 \\ X_4 & Y_4 & 0 & 1 \end{vmatrix} = \frac{1}{2}\begin{vmatrix} X_2 & Y_2 & 1 \\ X_3 & Y_3 & 1 \\ X_4 & Y_4 & 1 \end{vmatrix} + \frac{1}{2}\begin{vmatrix} X_1 & Y_1 & 1 \\ X_2 & Y_2 & 1 \\ X_4 & Y_4 & 1 \end{vmatrix} = A_1 + A$$



SCIENCE QUESTIONS

June, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue Cleveland, Ohio

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio. Thanks.

GUILD QUESTION RAISERS AND ANSWERS (GQRA)

Individuals and classes are eligible.

Join by sending in a question or an answer.

Let your classes get into this interesting game.

Send in your question NOW. JOIN THE GQRA!!

The GQRA was first referred to in January, 1934, at which time thirteen (13) contributors to *Science Questions* were named as Charter Members. All had contributed within three months, or in October, November, or December, 1933.

In June, 1934, it had thirty-nine (39) members.

In June, 1935, it has ninety-two (92) members—a gain of 53 for the year.

The first class contribution came from Norwich Free Academy.

The first class answer came from Gilmer, Texas.

Both classes are on the list of charter members.

Woodbine High School Physics class proposed a set of questions "difficult to explain" (Question 659, May, 1934).

Hirsch High School, Chicago, has five (5) members; Brookline High School three (3); Rizal High School, P. I., five (5); Albion High School three (3); Riverside High School fifteen (15) contributors. Congratulations!!!!

First place for the year goes to Riverside High School, Buffalo, N.Y., Mr. Louis T. Masson, Chairman, Science Department.

New Members in June, 1935 (GQRA Nos. 86 to 92 are;—Leonard Niemer, Riverside H. S.; Edward Roth, Riverside H. S.; J. Byers King, Corsica, Pa.; Albert Voros, Riverside H. S.; Clay Herrick, Jr., Cleveland;

Norman S. Greiner, Somerville H. S.; Leona Millard, James Ford Rhodes H. S., Cleveland.

VACATION QUESTIONS

716. *Contributed by Leona Millard, James Ford Rhodes High School, Cleveland, Ohio. (Elected to GQRA, No. 92)*

ARE YOU A SHERLOCK HOLMES?

A young man and his wife started from England for a vacation in the Swiss Alps. While climbing a mountain the woman fell over a cliff and was killed. The Swiss Coroner decided that the death was accidental and it was so reported in Continental papers.

Back in England a man read this newspaper report and informed the police that the husband had murdered his wife, which turned out to be the case.

What mistake did the husband make which caused him to be detected in murder?

Carl E. Heilman, (GQRA No. 55), also contributes two "think" questions, which will be published in a later number.

What "think" questions have you?

717. *Submitted by W. C. Hawthorne, Chicago, Ill. (GQRA No. 67)*

A better meringue is made by vigorously whipping the mixture of sugar and egg-white for a few minutes, then setting it aside for a short time, then repeating the operation, etc., than when the whipping is continuous. Explain. (There is a real physico-chemical explanation.)

A SET OF QUINTUPLETS

718. *Submitted by Loretta Beltek, (GQRA No. 79), Riverside High School, Buffalo, N. Y.*

Five more "easy questions." State the physics principles involved in each.

1. An iron nail sinks in water but floats in mercury.
2. A hydrogen bubble will not rise indefinitely.
3. It is more dangerous to stand up in a canoe than in a rowboat.
4. A man leans forward when climbing a steep hill and backward when descending.
5. A tight-rope walker carries a pole or parasol.

WHAT ARE PUPILS THINKING ABOUT?

Some of the questions and answers in this issue point out what some pupils in some classes will think about if given a chance to express themselves. The pages of *Science Questions* are open to them.

Dear Mr. Franklin T. Jones:

I am a pupil in the Buffalo Riverside High School and in response to your questions, I am sending in answers to them that I think are correct.

684. *When an irresistible force strikes an immovable object, what will happen?*

Absolutely nothing will result when the irresistible force strikes the immovable object.

685. *Two boys stand together out in the middle of a lake on the surface of level ice with ice skates attached to their shoes. Suppose that the movement of the skates on the ice is frictionless, without taking off their skates or calling for external help, how can they get off the ice?*

As long as their skates are frictionless and they are standing together on the ice, the solution is easy, for all they have to do is to give each other a good push at the same time, and they will glide over the ice until they hit land. They can not stop gcing after once in motion because of the Law of Inertia and because of the lack of friction.

I am a pupil of Mr. Louis T. Masson in Physics. I am intending to send in some questions in the very near future. I remain,

Very truly yours,

Edmund W. Mioducki (GQRA No. 73)

SOME MORE TOO EASY PROBLEMS

In May, 1934, Questions 654–655–656–657 and 658 repeated Roecker's Questions 1–5 (February, 1934, S. S. & M.).

Here are a few more of these "too easy" questions.

669. (6) When a cubic foot of water is warmed 1 degree Fahrenheit how many BTU are needed?

670. (7) The vacuum in a thermos bottle does not prevent heat transfer by ....

671. (8) What is the reading of absolute zero on the centigrade scale?

672. (9) A boat weighing 625 pounds displaces how much water?

673.(10) The center of gravity of a vase is........................ when flowers are put into it.

Mr. Blanchard has expressed his opinion on the reasons "Why Pupils Fail." What do you think about it? (S. S. & M. October, 1934).

Answers by Douglas Ort, (Elected by GQRA No. 71) Riverside H. S., Buffalo, N. Y.

The following are answers to the "easy problems" which appeared in the October, 1934 issue of SCHOOL SCIENCE AND MATHEMATICS magazine.

669. (6) When a cubic foot of water is warmed 1 degree Fahrenheit, 62.4 BTU are used.

670. (7) The vacuum in a thermos bottle doesn't prevent heat transfer by radiation.

671. (8) The reading of absolute zero on the centigrade scale is $-273°C$.

672. (9) A boat weighing 625 pounds displaces 100.16 cu. ft. of water.

673. (10) The center of gravity of a vase is raised when flowers are put into it.

P.S. In problems **669**(6) and **672**(9) I took a cubic foot of pure water to weigh 62.4 lbs., as I was taught.

TOO EASY QUESTIONS

"Why the Failures?" asks a teacher—(A continuation of questions separately numbered which were originally published as No. 643.)

694. (11) A lever 6 feet long has its fulcrum 6 inches from one end. What is its Mechanical Advantage?

695. (12) How much work is done in pushing a 100-pound trunk 4 feet along the floor with a force of 40 pounds?
696. (13) Define foot-pound.
697. (14) A highway with a 2% grade rises............ feet in a mile.
698. (15) State Archimedes' principle.

Solution from Riverside High School, Buffalo, N. Y.

Dear Mr. Jones:

I am very proud to become a member of your club and will certainly try to be an active one. I am submitting the following answers from the April issue from 694–698.

694 (11) $MA = \frac{66''}{6''} = 11MA$ answer.

695 (12) Work = Force × Distance
$x = 40 \times 4$
$x = 160$ ft. lbs. 2% rise in 100 ft.

697. (13) $52.80 \times 2 = 105.60$ feet, rise in grade in a mile.

698. (15) Archimedes' Principle—A body immersed in a fluid loses as much weight as the weight of the fluid it displaces.

Your GQRA Member 74, Ernest Bodnar.

PERPETUAL MOTION PROBLEM

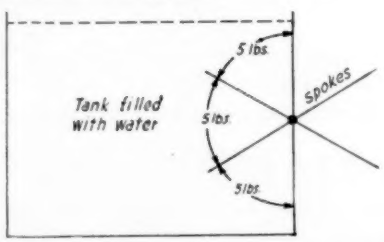
699. *Proposed by O. B. Rose, Garrett High School, Garrett, Indiana (Elected to GQRA No. 61.)*

The following problem has proven to be rather puzzling to many Physics tudents.

A wooden wheel is pivoted on the side of a tank of water so that one-half revolves in the water and the other half in air. Of course wood rises in water and falls in air. Why will not the wheel revolve, thus producing perpetual motion?

Solution by Albert Voros, (Elected to GQRA, No. 89), Riverside High School

This is my solution to question 699. I will endeavor to prove my statements with the aid of a diagram.



If the wheel was suspended in the same element, it would remain in equilibrium. If it were possible to fix a wheel in the manner explained so that it would not allow water to escape, it would be expected that the wheel would turn. This is made impossible by Newton's third law of motion; to every action there is an equal and opposite reaction. Let us imagine that the water has a buoyant force of five pounds against the wooden spokes, then according to Newton's third law of motion there is a reaction of five pounds transmitted with undiminished force. The spoke about to enter would be opposed by a force of five pounds, thus the wheel remains in equilibrium; the wheel will not rotate.

715. *Proposed by Robert H. Grimes, Riverside H. S. Buffalo, N. Y. (Elected to GQRA No. 76.)*

I wish to become a member of the GQRA. I am submitting this question.

We are told that by reducing the air pressure about a boiling liquid, the temperature at which it boils is lowered. That is water can be made to boil at 100° C, 90° C, 80° C, etc. By reducing the pressure sufficiently, can water be made to boil and freeze at O° C at the same time?

Answer by Jack Doran. (Elected to GQRA, No. 84) Riverside H. S., Buffalo, N. Y.

In reply to the question submitted by a member of our Physics class, "whether it is possible for water (or any other liquid) to boil and freeze at the same time," I am sending you my answer.

The boiling point of a liquid is defined as the temperature at which the pressure of its vapor is equal to the atmospheric pressure. For water this is 100 degrees centigrade or 212 degrees Fahrenheit. By placing the boiling water under the receiver of an air pump the so-called "atmosphere" above the liquid can be "thinned out." The water consequently will continue boiling at a lower temperature making the boiling point of 100 degrees centigrade gradually approach zero degrees centigrade, the freezing point. If the process of evacuation is carried out sufficiently a very slow and sluggish boiling effect will be seen, while a thin slushy layer of ice forms at the top and the thermometer records a temperature of zero degrees centigrade. It is therefore possible to boil and freeze water at the same time.

HEAVY WATER FOR SALE

686. *From an advertisement on page x, April* **1934**, *"The Review of Scientific Instruments."*

A manufacturer of chemicals says:

"We have available for immediate shipment, a quantity of this new and interesting material (deuterium oxide) in the following concentrations: .05 mol per cent; .10 mol per cent; .47 mol per cent; also 95% or better."

(1) What is deuterium oxide?

(2) What does the expression ".05 mol per cent" mean?

(3) What interesting experiments have been performed with "heavy water"?

Answer by Chas C. D'Amico, (GQRA No. 49) Albion, N. Y.

(1) Until a year or so ago only one kind of atom of the element hydrogen was known, and water is hydrogen oxide—H_2O. It was then found that there is also an isotope of hydrogen, a hydrogen atom which is just twice as heavy as so called ordinary hydrogen. It acts chemically like ordinary hydrogen, but since it is so much heavier than ordinary hydrogen, it can be separated mechanically from liquid hydrogen. To distinguish this heavy hydrogen from ordinary hydrogen, it is called Deuterium and is represented by the letter D. Deuterium oxide is written D_2O to distinguish it from ordinary hydrogen oxide or water. D_2O or DHO also represents water. Prof. Lewis of the University of Cal. has concentrated a form of heavy water whose density is 1.1074 gm/cc. (Density of 99.5% D_2O is 1.1074); ordinary water has a density of 1 gm/cc. The physical properties of heavy water or D_2O are different from those of ordinary water. It is

heavier, it boils and freezes at higher temperatures, and substances are less soluble in it. Professors H. Taylor and E. Harvey of Princeton University have carried out and performed many interesting experiments with heavy water. They found heavy water to be toxic to both plant and animal life; seeds do not germinate when moistened with it. It is thought to be the cause of old age. At first no one dared to drink it. But lately it has been taken into the human body and has proven harmless. Since there are isotopes of oxygen, namely nos. 15, 16, and 17 and since the existence of hydrogen of atomic number 3 has recently been announced by the Cavendish Laboratory in England, combinations of the three isotopes of oxygen with the three isotopes of hydrogen make possible the existence of many different varieties of water. It is readily seen that with the introduction of so many isotopes modern chemistry becomes much more complex.

The expression ".05 mol per cent" is based on our definition of a molar solution. The letter *M*, or the word Mol or Mole, is often used to express a molar solution. The molar strength of a solution is obtained by dividing the number of grams of the solute in 1 liter of the solution by the gram-molecular weight of the solute and expressed as a percent.

Comments from Laboratory of Ohio Chemical & Mfg. Co., Cleveland.

With regard to the questions and answers on Heavy Water which you left with the writer for examination by our laboratory, we are enclosing same with comments by our chief chemist.

He differs from Mr. D'Amico with respect to the density of Heavy Water of 99.5% and with reference to the isolation of the isotopes of Oxygen; namely, Nos. O_{15}, O_{16}, O_{17}, and O_{18}; otherwise, we feel that this answer is fairly complete and concise.

Mention might be made that it was Professor Harold C. Urey of Columbia University who discovered Heavy Water and who was awarded the Novel prize in 1934 for this discovery. Further mention might be made that a "light water" is now being produced containing no traces of Heavy Hydrogen.

As is the case with Heavy Water, no economic value or use has been found for "light water" as yet, but experiments are constantly being made.

Trusting that this information will prove useful and interesting to you and your readers, we are,

Yours very truly,
THE OHIO CHEMICAL & MANUFACTURING CO.
Clay Herrick Jr. (Elected to GQRA No. 90.)

ENGINEERS DISAGREE

689. *Proposed by John C. Packard, (GQRA No. 1) Brookline, Mass.*

Reported to me that two college men argued for two hours over this problem. A $1\frac{1}{4}$ in. pipe, with strainer attached, is driven into the ground for an artesian well. Water rises to within 20 ft. of the top of the pipe. It is proposed to use an electric pump, having a $\frac{3}{4}$ in. supply pipe attached, to bring the water to the surface. Query: should the supply pipe be attached, direct, to the top of the $1\frac{1}{4}$ in. pipe by a reduced coupling or should the $\frac{3}{4}$ in. supply pipe be made long enough to reach down into the water and be placed inside the $1\frac{1}{4}$ in. pipe? Why?

ED. JONES paid a plumber for 15 hours work for fixing a pump that was connected up wrong as intimated above. The plumber "repaired the valves." What should he have done? Actually, the next time he brought

a second plumber to help him. Now, after pumping a pail-and-a-half of water, pumping stops. Why? After priming you can start the pump and get another pail-and-a-half. How much should ED pay the second plumber?

Answer to the Pump Problem by John C. Packard, (GQRA No. 1) Brookline, Mass.

Cap the top of the 2½ in. pipe. Introduce a T-coupling, 2½ by ¾, 2 ft. below the top of the pipe. Attach the suction pipe of the electric pump to the ¾ in. opening and go ahead. "Results" guaranteed.

Editor should have "pumped" the plumber as to his intentions before signing the contract.

CLAIMED AS PHYSICS PROBLEMS

690. *Proposed by Maxwell Reade, (GQRA, No. 47) Brooklyn, N. Y.*
"Here are two cute problems."

I. The velocity of the Extremity of the minute hand is 16 times that of the hour hand, which is 3 inches long. How long is the minute hand?

II. A train is running on a horizontal track at 30 m.p.h. when the steam is suddenly shut off. How far will train run before it stops? (If the resistance to its motion is equal to 16 lb. force per ton of mass of train.)

Solution by Norman S. Greiner, (Elected to GQRA, No. 91) Somerville H. S., Somerville, N. J.

I. Let: v_1 = velocity (ft./sec.) of extremity of min. hand.
w_1 = angular vel. (rad./sec.) of min. hand.
r_1 = length of min. hand.
Let: v_2 = vel. (ft./sec.) of extremity of hr. hand
w_2 = angular vel. (rad./sec.) of hr. hand.
r_2 = length of hr. hand.

then $v_1 = w_1 r_1$ (1)
and $v_2 = w_2 r_2$
but $v_1 = 16v_2$,
and $w_1 = 12w_2$,
and $r_2 = 3''$,
$\therefore v_2 = 3w_2$

Substituting in (1)
$16v_2 = w_1 r_1$
or $48w_2 = 12w_2 r_1$
$r_1 = 4''$

Charles C. D'Amico, (GQRA, No. 49) says: "I measured the minute and hour hands of my kitchen clock and, to my surprise, their lengths were in the ratio of 4:3."

II. Let m = mass of train in tons
v = vel. of train in ft./sec.
g = accel. of gravity in ft./sec./sec.
f = force (in lbs.) resisting motion of train
s = dist. in ft. train travels before stopping.

then $fs = \dfrac{2000mv^2}{2g}$

$f = 16m$
$v = 44$ ft./sec.

$$16ms = \frac{2000m \times 44 \times 44}{64}$$

$$\therefore s = 3781.25 \text{ ft. Ans.}$$

Answers by Charles C. D'Amico—"The train will run 3779.6 ft. or 1259.8 yds. before it stops. Therefore, answer is approximately 1260 yards."

GAS METER PROBLEM

700. *Proposed by Allan J. Rosenthal, Senior Physics Class, Brookline High School, Brookline, Mass.* (*GQRA No.* **65**.)

A, *B*, *C* and *D* are four gas meters in the same apartment house and on the same gas line. *A* and *B* are in the attic—six stories above the street. *C* and *D* are in the basement. *A* and *C* are kept at an average temperature of 70° F; *B* and *D* at 35° F. The gas is used in each instance to supply fuel for a kitchen range. The gas company's charges are at the rate of one dollar per thousand cubic feet. Which customer gets the most for his money?

Solution by "A Chemist" was published in May, 1935.

Comment by A. J. Rosenthal. (GQRA. No. 65.)

The question was intended to be stated as written in order that we might have two meters at the same level but at different temperatures and two meters at the same temperatures but at different levels. See Black and Davis Pg. 116–Prob. 20. It is assumed that the tenants meter is to be in his apartment or near it—in other words "on the premises." Each is to pay for the cubic foot *as measured* by the commercial meter installed by the Gas Co.

Comment by J. C. Packard, Brookline, (GQRA. No. 1). "Meter problem seems to have disconcerted Ohio. Answer from Massachusetts later."

Comment by G. W. Warner, Chicago (GQRA, No. 18). "I do not think the gas man gave the correct answer. No reason why the attic meter and basement meter might not be at same temperature."

Jones says: "Look around and find a gas meter in the attic, or anywhere except the basement."

Who else has a comment?

BOOKS RECEIVED

The Structure and Properties of Matter, by Herman T. Briscoe, Professor of Chemistry, Indiana University. First Edition. Cloth. Pages x+420. 13.5×20.5 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.75.

Mathematics for Everyday Use, by John C. Stone and Virgil S. Mallory, State Teachers College, Montclair, New Jersey. Cloth. Pages xi+532. 12.5×19 cm. 1935. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago, Illinois. Price $1.28.

Science by Observation and Experiment, by Hanor A. Webb, Professor of the Teaching of Chemistry and General Science, George Peabody College for Teachers, and Robert O. Beauchamp, Instructor in Science, The Demonstration School, George Peabody College for Teachers. Cloth.

Pages xxii+697. 12.5×20 cm. 1935. D. Appleton-Century Company, Inc., 44 Hewes Street, Brooklyn, New York.

A Textbook of General Botany, by Gilbert M. Smith, Stanford University and James B. Overton, Edward M. Gilbert, Rollin H. Denniston, George S. Bryan, Charles E. Allen, University of Wisconsin. Third Edition. Cloth. Pages x+574. 14.5×22 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

A Laboratory Manual of General Botany, by Emma L. Fisk, University of Wisconsin, and Ruth M. Addoms, Duke University. Revised Edition. Cloth. Pages x+137. 14×22 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.00.

Man's Control of His Environment, by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neuner, Supervisor of Elementary Science, New Rochelle, New York; and Herbert Bascom Bruner, Professor of Education, Teachers College, Columbia University. Cloth. Pages xiv+753+32. 13×20 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $.60.

The Calculus, by Hans H. Dalaker, Professor of Mathematics and Mechanics, University of Minnesota, and Henry E. Hartig Associate Professor of Electrical Engineering, University of Minnesota. Third Edition. Cloth. Pages viii+276. 14.5×23 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.25.

Junior Mathematics for Today, Book Three, by William Betz, Vice-Principal of the East High School and Specialist in Mathematics for the Public Schools of Rochester, New York. Cloth. Pages xiv+562. 12×18.5 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $1.24.

Economic Geography, by Clarence Fielden Jones, Professor of Economic Geography, Clark University. Cloth. Pages xiv+448. 15×23.5 cm. 1935. Henry Holt and Company, One Park Avenue, New York, N. Y.

Modern School Mathematics, by Ralph Schorling, Head of Department of Mathematics, The University High School, and Professor of Education, University of Michigan; John R. Clark, The Lincoln School of Teachers College, Columbia University; with the coöperation of Rolland R. Smith, Specialist in Mathematics, Public Schools, Springfield Mass. Cloth. 12.5×18.5 cm. Book I, pages xx+364. Book II, pages xvi+368. 1935. World Book Company, Yonkers-on-Hudson, New York. Price each 92 cents.

The National Council of Teachers of Mathematics Tenth Yearbook, The Teaching of Arithmetic. Cloth. Pages vi+289. 15×23 cm. 1935. Bureau of Publications, Teachers College, Columbia University, New York, N. Y.

Community Programs for Summer Play Schools, by LeRoy E. Bowman, Director of Extension Activities, and Edited by Benjamin C. Gruenberg. Paper. Pages v+48. 15×23 cm. 1935. Child Study Association of America, 221 West 57th Street, New York, N. Y. Price 35 cents.

BOOK REVIEWS

The Teaching of Biology, by William E. Cole, Associate Professor of Science Education, University of Tennessee. 252 pages. D. Appleton-Century Company, Inc., 35 West 32nd Street, New York.

The idea has been quite prevalent that a person well grounded in the university in the principles and facts of science will be a successful teacher when placed in a position in the high school. The futility of this assumption is becoming more and more evident in recent years, as many of us have learned from early experiences in applying college methods to secondary school situations. In view of these facts, this book on method

in high school biology teaching is of inestimable value, as it brings together information and establishes a point of view which otherwise could only be gained slowly by years of experience and experimentation. The point of view is thoroughly up-to-date. The emphasis is placed on principles rather than on details of technique.

The treatment includes, status of biology in the secondary school, persent and past; problem of objectives; selection and use of subject matter; methods of the classroom and in the laboratory; tests and measurements; together with standards of evaluation of the teacher and the subject. The teacher aids of the appendix, such as bibliographies of books and magazines, survey blanks, teacher-rating scale, and directions for fitting-up the laboratory and preserving biological specimens is, in itself, worth many times the price of the book.

The book should prove an invaluable aid to all teachers, experienced or inexperienced, as they meet the problems in the teaching of the biological sciences in the secondary schools and in the general courses of the junior college.

JEROME ISENBARGER

Physics of the Home, by Frederick A. Osborn, Ph.D., Professor of Physics, University of Washington. Cloth. 14×21 cm. pages xii+441. 1935. McGraw-Hill Book Company, New York, N. Y. Price $3.00.

The old question "Why should girls study physics" receives an answer daily in the application of things scientific and technical in the home. In the past we have been satisfied in using our regular text and supplement our lecture with some applications. However, we are not all equally alert to see the multiplicity of things physical in our homes. Physics of the Home is the first attempt to correlate theoretical and practical implications to meet the needs of women students who want to know Physics not for its own sake but for its real help in their daily life.

The order of the material follows that of the standard college text; Mechanics and Sound, Heat, Light, and Electricity. Numerous diagrams and photographs are found through the text, many with special reference to the home. As an example of the authors method of treatment the reviewer cites the chapter on Elasticity in which the author departs from the conventional topics covered and devotes the major portion of his time to a study of fibers in fabrics. This is intensely practical and just as valuable as the "old" from an educational point of view. This treatment is typical of the entire text.

The book is designed to cover two quarters in the sophomore year in college. However, the material is so practical and presented so lucidly that the text could be used with equal success in a class of senior high school girls in home economics.

C. RADIUS

An Introductory Course in College Physics, by Newton Henry Black, Assistant Professor of Physics, Harvard University and Radcliffe College. Cloth. Pages viii+714. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

Teachers familiar with the very successful high school text, *Practical Physics* by Black and Davis will recognize the similarity of this college text to its forerunner. But it is not merely a high school text somewhat grown up even though the author has prepared it especially for those college students who have not studied physics in high school. Such topics as rotary motion, alternating current theory, spectroscopy, and atomic structure are discussed in sufficient detail to meet the needs of the liberal

arts or pre-medic student. There is a recognized need for a book of this type since a large percent of the students in general college physics have not had high school physics unless it is prerequisite to registration in the college class. Practically no mathematics is used except simple algebra and geometry. Elementary trigonometry is used in concurrent force problems and the index of refraction. The outstanding characteristics of the book are language of exceptional simplicity and clarity, use of simple experiments and of concrete illustrations from daily experience to introduce abstract concepts, emphasis on fundamental principles and their applications, an unusual number of good drawings, short chapters, a summary of each chapter, an excellent set of numerical problems following each chapter and based directly on the principles discussed, a set of references to interesting books on the topics of each chapter. The appendix contains physical data for use with the problems, a three-place sine and tangent table, and a four-place log table.

G. W. W.

Shop Projects in Electricity, by Herbert G. Lehmann, Teacher of Shop Science, Bronxville Schools, Bronxville, N. Y. Cloth. Pages x+190. 16×22 cm. 1934. American Book Company, 330 East 22nd Street, Chicago, Ill. Price 96 cents.

This is an electrical shop manual for junior high school classes. It consists of directions for making twenty-one pieces of magnetic and electrical apparatus, starting out with a simple little pocket compass and ending with a one-tube radio receiver. Other projects include a sensitive galvanometer, a rheostat, an electric engine, a serviceable transformer, and a 110-volt synchronous motor. Complete directions accompany each project, with elaborate diagrams, exact dimensions, an interesting introductory story, helpful questions and answers. Many a shop teacher who has not had as complete a preparation for electric shop work as is desirable will find this the answer to his prayer.

G. W. W.

Exploring With the Microscope, by Raymond F. Yates, Author of "Boys' Book of Model Boats" and "The Complete Radio Book." Cloth. Pages xv+182. 125×19 cm. 1934. D. Appleton-Century Company, 35 West 32nd Street, New York. Price $2.00.

This is an extremely fascinating book for the beginner, old or young, who wants to learn about the microscopic wonders of the world. It tells how to build a simple microscope at very small cost, if a commercial instrument is out of the question. It also tells the more fortunate what to purchase. Several pages are given to use and care of the instrument. Directions with drawings are given for constructing many accessories such as an illuminator, water cell, drying stand, microtome, dissecting microscope, etc. Instructions are given for collecting and preparing specimens, taking photo-micrographs, and other interesting and instructive processes. The author even goes so far as to include a chapter on the use of polarized light in microscopic investigations. The entire book is written in a style meant to attract the interest of the amateur. It is a real find for hobby hunters.

G. W. W.

Differential Geometry, by William C. Graustein, Professor of Mathematics, Harvard University. Cloth. Pages xi+230. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

This book deals with the metric differential geometry of curves and

surfaces in a three dimensional Euclidean space in terms of a vector notation. This vector notation is explained in about 10 pages of the introductory chapter.

The book contains the material of an introductory course which the author is accustomed to give over a period of a half-year. On the part of the reader it presupposes a knowledge of the fundamentals of the calculus and the elements of solid analytic geometry.

The contents of the course are indicated by the following chapter headings: Introduction; Space Curves; Curves and Surfaces associated with a Space Curve; Fundamentals of the Theory of Surfaces; The Fundamental Theorem; Geodesic Curvature. Geodesics; Mapping of Surfaces; The Absolute Geometry of a Surface; Surfaces of a Special Type.

Teachers of secondary mathematics who are not familiar with metric differential geometry and who wish to become acquainted with the fundamentals of this field will find a concise and elegant treatment of the subject in this book.

J. M. KINNEY

Brief Analytic Geometry, by Thomas E. Mason, Professor of Mathematics, Purdue University, and Clifton T. Hazard, Associate Professor of Mathematics, Purdue University. Cloth. Pages xi+196. 14×21 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $2.00.

This book is an abridgement of the authors' Analytic Geometry. This abridgement consists in the omission of the chapter on Tangents, Normals, Diameters, Poles and Polars and the chapter on Empirical Equations. Enough material has been supplied to prepare students for the calculus and at the same time give them some insight into the methods of analytic geometry.

There are three chapters which are arranged in the following order: The Point, The Straight Line; Equation and Locus; The Circle; Other Second Degree Curves; Other Types of Curves in Rectangular Coordinates; Parametric Equations; Polar Equations; Points, Planes and Lines; and Surfaces and Curves.

There are numerous exercises and figures. The book has an attractive appearance. The reviewer feels that it is well adapted to do the work for which it is intended.

J. M. KINNEY

A Brief Course in College Algebra, by Walter Burton Ford, Professor of Mathematics in the University of Michigan. Third Edition. Pages viii+304. The Macmillan Company, New York. 1935. Price $1.90.

This text has been prepared with two main objectives in mind. (1) To bring college algebra into the closest possible contact with the affairs of daily life, and (2) to correlate the subject with those central facts from elementary geometry which the student must know at all times if he is to succeed in college mathematics.

These objectives have been carried through the book by the skillful use of subject matter that has been made attractive and disciplinary. Necessary and sufficient introductions and solutions of examples make the book worthwhile. The applied problems are practical, useful, thought provoking, and stimulate that desirable type of mathematical application that brings about intense interest and mastery.

The text is sufficiently flexible to permit the instructor to vary the teaching material according to the needs or the previous training of students

beginning college algebra. The various chapters have been made independent of each other, as far as possible, thus permitting a ready adjustment of the book to either a long or a short course.

The changes introduced in the third edition, revised, are chiefly in the nature of an entire reconstruction of the exercise lists, each now containing material which, in the main, is new and each being of considerably greater length than formerly.

JOSEPH J. URBANCEK

Solid Mensuration, by Willis F. Kern, Instructor of Mathematics, and James R. Bland, Assistant Professor of Mathematics, both of the U. S. Naval Academy. Pages v+73. 14×21.5 cm. Paper. 1934. John Wiley and Sons, Inc., 440 Fourth Avenue, New York.

This book presents in concise form the practical essentials of solid geometry. The various solids and surfaces are defined and briefly described. Numerous concrete and practical problems based on each type have been assembled. Throughout the text we find a large number of excellent drawings.

The book may be used profitably in conjunction with the regular text in solid geometry. It may also be used by students who having completed a course in solid geometry with to correlate their geometric ideas.

J. M. KINNEY

A Textbook of General Botany, by Gilbert M. Smith, Stanford University and James B. Overton, Edward M. Gilbert, Rollin H. Denniston, George S. Bryan, and Charles E. Allen of the University of Wisconsin. Third edition, Cloth 8vo., 574 pages, and 429 illustrations in the text with full page photographic figures of eminent botanists. Published by The Macmillan Company, New York. 1935. Price $3.50.

This text is the outcome of several years experience by the authors in the teaching of first courses in botany, in the University of Wisconsin. The earlier editions have been very carefully revised and enlarged to incorporate statements of new discoveries and new viewpoints, but by omitting some less important topics the book has been kept within its former size. The usual order of presentation of the topics is followed beginning with a discussion of the "make-up" of a seed plant followed by chapters on the cell, roots, stems, etc. Then there are other chapters on the physiology of the plant, and finally the divisions of the plant kingdom are considered in order, closing with chapters on evolution, inheritance and the "economic significance of plants."

The illustrations are clear and numerous throughout the book. We may call this a very sane and efficient presentation of the subject of general botany—worthy of a place in the library of all teachers of botany as well as in first-year classes in botany in the college or university.

W. WHITNEY

A Laboratory Manual of General Botany, by Emma L. Fisk, University of Wisconsin, and Ruth M. Addoms, Duke University. Revised Edition. Cloth, x+137 pages. Published by The Macmillan Company. New York 1935. Price $1.00.

This manual is written to accompany *A Textbook of General Botany* by Smith, Overton, Gilbert, Denniston, Bryan and Allen. Third edition. It may of course be used with other texts. The manual is the outgrowth of privately printed manuals used in the classes in elementary college botany in the University of Wisconsin. The flowering plants are used to

introduce the work. It is planned for a year's course, but can be adapted to a shorter course by suitable omissions.

The work required of the students is very carefully planned and explanations and information are freely used to clarify the work to the student. The text is clear and concise. There is an appendix accompanying the exercises, containing suggestions for the selection and preparation of the material required for the exercises. There is also a list of formulas and preservatives used in the work.

We highly commend this manual for the painstaking care with which the exercises have been prepared.

W. WHITNEY

The Department of Science Instruction of the National Education Association

PROGRAM

MONDAY, JULY 1

Rose Room, Albany Hotel—2:00 P.M.

THE NEEDS AND PROVISIONS FOR UNIVERSAL SCIENCE EDUCATION
Otis W. Caldwell, Teachers College, Columbia University and General Secretary, American Association for the Advancement of Science. 30 minutes.

SCIENCE IN THE ELEMENTARY SCHOOLS OF CLEVELAND, OHIO
Mary Melrose, Supervisor of Elementary Science. 15 minutes.

SCIENCE IN THE ELEMENTARY SCHOOLS OF AUSTIN, TEXAS
Vesta Hicks, Supervisor of Elementary Science. 15 minutes.

SCIENCE IN THE ELEMENTARY SCHOOLS OF TULSA, OKLAHOMA
Mrs. Arlyne Morgan, Riverview School. 15 minutes.

SCIENCE IN THE ELEMENTARY SCHOOLS OF DENVER, COLORADO
Cora M. Meyers, Washington Park School. 15 minutes.

ELEMENTARY SCIENCE NEEDS AN OUTDOOR LABORATORY
Esther W. Scott, Supervisor of Elementary Science, Washington, D.C. 15 minutes.

THE RESEARCH PROGRAM TO DETERMINE GRADE PLACEMENT OF SUBJECT MATERIAL
Ralph C. Bedell, State Teachers College, Kirksville, Missouri. Chairman of the Research Committee of the Department of Science Instruction. 15 minutes.

Reports and Announcements
(Groups will be organized to discuss problems presented in the program.)

TUESDAY, JULY 2

Rose Room—Albany Hotel—2:00 P.M.

TRAINING TEACHERS TO MEET THE NEW DEMANDS IN SCIENCE EDUCATION
F. C. Jean, Head of Science Division, State Teachers College, Greeley, Colorado. 25 minutes.

A BASIS FOR THE CRITICAL EVALUATION OF THE PRESENT PROGRAMS IN JUNIOR HIGH SCHOOL SCIENCE
Anita D. Laton, Supervisor of Science in the University High School and Lecturer in Education, University of California. 20 minutes.

SCIENCE IN THE JUNIOR HIGH SCHOOLS OF ROCHESTER, N. Y.
Harry A. Carpenter, Supervisor of Science. 15 minutes.

SCIENCE IN THE JUNIOR HIGH SCHOOLS OF WYOMING
N. S. Stout, Junior High School, Cheyenne. 15 minutes.
SCIENCE IN THE JUNIOR HIGH SCHOOLS OF TULSA, OKLAHOMA
Mrs. Lillian Kennedy, Woodrow Wilson Junior High School. 15 minutes.
SCIENCE IN THE JUNIOR HIGH SCHOOLS OF DENVER, COLORADO
Helen Roberts, Horace Mann Junior High School. 15 minutes.
THE GARDEN, A LABORATORY FOR JUNIOR HIGH SCHOOL SCIENCE
Elizabeth Downhour, Butler University. 15 minutes.
Business meeting and Election of Officers.
(Groups will be organized to discuss problesms raised.)

TUESDAY EVENING—6:15 P.M.

RECEPTION-BANQUET
AND
FORTIETH ANNIVERSARY CELEBRATION

For Members of Department of Science Instruction and Visiting Teachers.

Rose Room, Albany Hotel. Tickets $1.50 which also includes the excursion on Wednesday, July 3.
Sponsored by the Teachers of Denver and Colorado—Ray K. Easley, Chairman
Address—"SCIENCE IN THE FUTURE JUNIOR COLLEGE"
William J. Bogan, Superintendent of Schools, Chicago, Illinois
(Make reservations with Ray K. Easley, East High School)

WEDNESDAY, JULY 3

Rose Room—Albany Hotel—1:00 P.M.

(Meeting starts early because of the excursion at 3:00 P.M.)
THE SOCIAL SIGNIFICANCE OF SCIENCE IINSTRUCTION
E. E. Bayles, Associate Professor of Education, University of Kansas. 25 minutes.
A CRITICAL EVALUATION OF THE PRESENT PROGRAMS IN SENIOR HIGH SCHOOL SCIENCE
J. H. Jensen, Head of Science Dpeartment, State Teachers College, Aberdeen, South Dakota. 20 minutes.
SCIENCE IN THE SENIOR HIGH SCHOOL OF LAFAYETTE, INDIANA
Morris McCarty, Superintendent of Schools. 15 minutes.
SCIENCE IN THE SENIOR HIGH SCHOOL OF DENVER
Robert Collier, South High School. 15 minutes.
SCIENCE IN THE CENTRAL SENIOR HIGH SCHOOL OF LIMA, OHIO
J. G. Crites, Head of Science Dpeartment. 15 minutes.
SCIENCE IN THE SENIOR HIGH SCHOOLS OF TULSA, OKLAHOMA
Gabriella Pratt, Central Senior High School. 15 minutes.
SCIENCE DIRECTION IN TULSA, OKLAHOMA
R. R. Spafford, Director of Science. 10 minutes.
Reports and Announcements.

EXCURSION

Wednesday, July 3—3:00 P.M.

This excursion is for members of the Department of Science Instruction and the number going is limited to the first *three hundred* who make reservation for the banquet at $1.50.
Sponsored by the Teachers of Colorado and Denver. F. C. Jean, Chairman.
Mr. Coors has invited the science teachers to visit his industrial plants at Golden, Colorado. Included in his industrial plants are the pottery

works, malted milk plant, and "Prope est aedificium ad cerevisiam coquendam exstructum." Dinner at Coors at 6 P. M. followed by a sightseeing tour of Lookout Mountain and Buffalo Bill Museum.

THURSDAY, JULY 4

Rose Room, Albany Hotel—2:00 P.M.

Joint Meeting with School Garden Association of America
Van Evrie Kilpatrick,, Pres., Director-Nature Education, New York City
E. Ruth Pyrtle, Vice President, Principal, Bancroft School Lincoln, Negraska.

THE SCHOOL GARDEN—THE LABORATORY OF ELEMENTARY SCIENCE
Willis A. Sutton, Superintendent of Schools, Atlanta, Georgia.

THE SCHOOL GARDEN TEACHES NATURE
Mildred Fahy, Principal, Von Steuben School, Chicago, Illinois.

THE SCHOOL GARDEN TEACHES THE BASIC INDUSTRY
Carl G. Howard, State Director for Vocational Education, Cheyenne, Wyoming.

THE SCHOOL GARDEN TRAINS FOR SELF-SUPPORT
Alexander J. Mueller, Schools of Los Angeles.

THE SCHOOL GARDEN TEACHES ELEMENTARY SCIENCE
Representative from Denver Local Committee.

SCHOOL GARDEN ACTIVITIES—ILLUSTRATED
M. I. Smith, Director Visual and Nature Education, Hibbing, Minnesota.

Discussion Leaders—Albert M. Shaw, Los Angeles; Karl H. Blanch, E. Mauch Chunk, Pa.; and Marvin M. Brooks, Public School 121, Queens, N. Y. C.

NEW CORRESPONDENCE COURSE IN FIELD ZOOLOGY

Many of us, whether living in town or country, though we have no professional interest in botany or zoology, love to tramp in woods or meadows, along streams or in the hills. Often we are curious about the animal life about us on such occasions and wish that we might know more about it.

Some of us, even as teachers in the nature sciences, have the same feeling. Equipped with book and laboratory knowledge we have never experienced the pleasure of field studies, of meeting our classroom and book friends among the insects, birds, and beasts in their own environment and observing them there.

This side of zoology it was which appealed to the early naturalists when man first began to notice that the vertebrates were not the only inhabitants of this globe. Also, it is this phase of zoology which appeals to the inquiring mind of young people of high school and college age. This appeal, unfortunately, we often stifle by unintentional repression in laboratory courses.

These considerations have prompted the Home-Study Department of the University of Chicago to develop a new course in Field Zoology. Though done by correspondence it will meet the needs and interests of laymen and teachers, of the young student group, and of the mature adult who has a bent toward nature. It is so designed that for all—the amateur and the professional—it will constitute an adventure in nature study. Also, it adapts itself to the regional nature environment of different individuals.

We look upon this course as an unusual opportunity and will gladly furnish further information as to content and method of instruction.

C. F. HUTH *Director*
Home-Study Department

NOTE ON THE EXPANSIONS OF SIN(A ±B) AND COS(A ±B)

By Howard D. Grossman, *New York City*

L. Richardson's article in the February issue suggests a still simpler derivation of Sin $(A \pm B)$ and Cos $(A \pm B)$ by the use of De Moivre's beautiful theorem.

Let $K_n = \cos n + i \sin n$

Then $K_1^{A \pm B} = K_1^A K_1^{\pm B}$

or $K_{A \pm B} = K_A K_{\pm B}$

I.e., $\cos(A \pm B) + i \sin(A \pm B) = (\cos A + i \sin A)(\cos B \pm i \sin B)$

Equating imaginary and real parts,

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B,$$
$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B.$$

If we watch the thoughts which come into our minds we shall find that they are of the same kind as those which we habitually encourage.—Annie Besant.

Common sense in an uncommon degree is what the world calls wisdom. —Coleridge.

Die when I may, I want it said of me by those who know me best, that I always plucked a thistle and planted a flower, where I thought a flower would grow.—Abraham Lincoln.